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1984 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

Edited by:
Brian G. Bue

September 1986

ALASKA DEPARTMENT OF FISH AND GAME
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Don W. Collinsworth
Commissioner

ADF&G TECHNICAL DATA REPORTS

This series of reports is designed to facilitate prompt reporting of data from studies conducted by the Alaska Department of Fish and Game, especially studies which may be of direct and immediate interest to scientists of other agencies.

The primary purpose of these reports is presentation of data. Description of programs and data collection methods is included only to the extent required for interpretation of the data. Analysis is generally limited to that necessary for clarification of data collection methods and interpretation of the basic data. No attempt is made in these reports to present analysis of the data relative to its ultimate or intended use.

Data presented in these reports is intended to be final, however, some revisions may occasionally be necessary. Minor revision will be made via errata sheets. Major revisions will be made in the form of revised reports.

1984 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

A summary of data collected from sockeye salmon (*Oncorhynchus nerka*) smolt programs in Bristol Bay, including Kvichak, Naknek, Egegik, Ugashik, Wood, and Nuyakuk Rivers.

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ABSTRACT

Sockeye salmon (*Oncorhynchus nerka*) smolt studies were conducted on the Kvichak, Naknek, Egegik, Ugashik, Wood, and Nuyakuk River systems within Bristol Bay, Alaska, during 1984. Estimates of numbers of smolt migrating to sea, based upon data obtained from sonar equipment, were 89,489,975 from Kvichak; 81,559,941 from Naknek; 49,667,432 from Egegik; 158,174,626 from Ugashik; 23,710,891 from Wood; and 6,383,556 from Nuyakuk. Fyke net samples indicated that age I smolt, from 1982 brood year spawning escapements, were the dominant age class in three out of the six river systems (percent of age I smolt; 58, Kvichak; 94, Wood; 99, Nuyakuk). Age II smolt, from 1981 escapements, were the dominant age class in the remaining three systems (percent of age II smolt: 60, Naknek; 65, Egegik; 52, Ugashik).

KEY WORDS: juvenile sockeye salmon, *Oncorhynchus nerka*, juvenile migration, sonar, Bristol Bay, Kvichak River, Naknek River, Egegik River, Ugashik River, Wood River, Nuyakuk River.

INTRODUCTION

This report is a continuation of a series of Alaska Department of Fish and Game Technical Data Reports documenting methods and results of projects conducted to estimate numbers and age composition of sockeye salmon (*Oncorhynchus nerka*) smolt migrating from Bristol Bay river and lake systems. Smolt data is used both to forecast adult returns and to estimate optimum spawning escapement for Bristol Bay freshwater systems. In 1984, sonar equipment was used to estimate the number of smolt migrating from the Kvichak, Naknek, Egegik, Ugashik, Wood, and Nuyakuk River systems. Fyke nets were used to capture samples of smolt to obtain age, length, and weight data. Smolt which have remained within freshwater for one winter after hatching will have formed one annual mark on their scales and are referred to as age I smolt. Smolt which have spent two winters within freshwater after hatching will have formed two annual marks and are referred to as age II smolt.

1984 KVICHAK RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

The number of seaward migrating sockeye salmon (*Oncorhynchus nerka*) smolt have been estimated by sonar for the Kvichak River system since 1971. Prior to 1971, fyke nets were used to calculate abundance indices (Kerns 1961; Russell 1972; Paulus and McCurdy 1972; Parker 1974a and 1974b). Abundance estimates and age composition data have been used to forecast adult returns and to estimate spawning escapement levels needed for optimum production.

Specific objectives of 1984 studies were to estimate the number of sockeye smolt migrating to sea, to determine the age composition of the smolts, to collect length and weight data for smolt, and to record climatological and hydrological data which could influence smolt migratory patterns.

MATERIALS AND METHODS

In 1984 a sonar system developed by the Bendix Corporation was used to estimate the number of juvenile salmon migrating past the study site. The sonar system consisted of a single control unit and three 3.3 m (11 ft) long plastic ladder-shaped arrays, each housing 14 transducers. The combined sonar beam produced by each array was 3.7 m (12.2 ft) wide. Arrays were anchored on the river bed, and their transducers were connected to the control unit with coaxial cables. Installation and operation of the gear followed procedures similar to those described by Randall (1977). The total number of sonar counts recorded by each array was printed by the control unit every 15 minutes. Sonar counts were converted to estimates of smolt numbers by subtracting false counts, interpolating counts during missed time periods, adjusting counts for differences in river velocity among arrays, expanding counts to estimate numbers of smolt passing the transect site in areas not covered by the sonar beams, and multiplying counts by the actual number of smolts which generated a single sonar count.

A disabling switch was used to turn off the sonar counting unit during times when ice, debris, boat traffic, etc., which generate false counts were passing over the array. The time, in seconds, that the unit was disabled was automatically printed at the end of each specified counting interval. The number of valid (smolt) sonar counts expected during periods when the unit was disabled was estimated by linear interpolation. False counts noted during times when the unit was not disabled were subtracted from period totals.

Water current velocities were measured behind each array three times during the season so that sonar pulse rate could be adjusted. This minimized over- and under-counting errors, since residence time of smolt within the sonar beam decreased as water current speed increased.

Counts from each array were expanded to estimate numbers of smolt migrating in sections of the river not covered by the arrays. Expansion of counts were based on the lateral distribution of smolt across the counting site transect, which was estimated visually and from information gathered from a side scanning sonar unit.

The sonar system was designed to count biomass rather than individual smolt, and was calibrated at the factory to register one count for the biomass equivalent of 10 smolt weighing a total of 83 g (based upon the weighted mean of all Kvichak smolt weight data available prior to 1971). In past studies, adjusted sonar counts were multiplied by 10 to obtain final estimates of smolt numbers. However, since mean smolt weight varied during the season as well as among years, more accurate final estimates of smolt numbers should be obtained using actual mean smolt weight data from daily fyke net catches. Therefore, daily adjusted smolt counts were multiplied by a correction factor (F):

$$F = 10 (8.3 / W), \text{ where}$$

W = daily mean weight of smolt from fyke net samples.

A 1.5 m by 1.5 m (5 ft by 5 ft) fyke net was fished downstream of the center and offshore sonar arrays. Captured smolt were identified according to species, weighed (g), measured (fork length, mm), and aged from scale samples. This data was used to apportion sonar counts according to age class and salmonid species.

Samples of at least 400 sockeye salmon smolt were used to estimate age class composition for each 24-hour sampling period. If this number of smolt was not captured during a 24-hour period, samples from subsequent periods were combined until a total of at least 400 smolt was obtained. Samples of 400 smolt produced estimates of the actual proportion of age I or age II smolt which were within 0.05 of the estimated proportion (at the 0.05 significance level) for actual age class proportion ranging from 0.95 to 0.05 (Bill et al. in press). Samples of this size also produced estimates of the actual number of either age I or II smolt which were within 50% of the estimated number (at the 0.05 significance level) for actual age class proportions ranging from 0.05 to 0.20, and which were within 15% of the estimated number (at the 0.05 significance level) for actual age class proportions ranging from 0.30 to 0.95.

To obtain daily age data for 400 sockeye salmon smolt it was necessary to decrease the time required for processing samples. Therefore, scale samples, and weight and length samples were obtained from about 150 smolt each day. An additional 250 smolt were measured for length data, but were not weighed or used for scale samples.

After the field season, smolt for which only length measurements had been obtained were assigned a weight and an age based upon analysis of available age, weight, and length data (Bill et al. 1986).

RESULTS AND DISCUSSION

A total of 1,655,493 sonar counts were recorded during the season (Table 1). The estimated total number of smolt was 89,489,975 (Table 2). Daily migration estimates exceeded 6.6 million sockeye salmon smolt per day during the period 21 May through 24 May, accounting for 32% of the smolt enumerated. The peak day of migration past the counting site occurred on 27 May, when 15% of the total estimated smolt population migrated seaward.

A total of 5,892 smolt were sampled to obtain data on age, length, and weight (Table 3). Age class composition of the total smolt population was estimated to be 58.0% age I (1982 brood year) 42.0% age II (1981 brood year). Mean lengths of age I and II smolt were 90 mm and 104 mm, respectively. Mean weights of age I and II smolt were 6.8 g and 10.0 g, respectively. The mean weight of age I smolt measured was greatest since 1975. The mean length and mean weight of age II smolt was 5 mm shorter and 0.8 g lighter than the overall means for 1955-1983 (Table 4).

Total estimated smolt production from the 1981 brood year spawning escapement of 1,754,358 sockeye salmon was 25.163 smolt per spawner (an estimated 6,549,125 age I smolt migrated to sea in 1983; 37,595,987 age II smolt migrated to sea in 1984) (Table 5).

Average marine survival for smolt produced by the 1969-1978 brood years has been 9.6% for age I smolt (i.e., an average of 0.096 adults have returned for each age I smolt produced), and 13.2% for age II (i.e., an average of 0.132 adults have returned for each age II smolt produced) (Table 6).

River and weather conditions were recorded at the sonar site from 19 May until 11 June (Table 7). The season was relatively ice free. Mean water temperature during the project was 7.9° C (range, 5.5 to 10.0° C). This was nearly identical to the 1983 observation, the third highest mean water temperature recorded since 1963 (mean, 1963-1982, 5.3° C) (Table 8). During peak migration of smolt, 21-24 May, mean water temperature at the counting site was between 6.3 and 7.6° C.

Table 1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Kvichak River, Bristol Bay, Alaska, 1984. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Sonar Counts				
Transducer Array				
Date 1/	Inshore	Center	Offshore	Total
5 18	6,163	21,081	7,077	34,321
5 19	7,005	8,085	9,449	24,539
5 20	3,645	13,641	9,559	26,845
5 21	16,723	55,943	65,716	138,382
5 22	28,880	68,534	56,207	153,621
5 23	42,489	57,263	34,075	133,827
5 24	25,518	73,701	22,804	122,023
5 25	9,575	46,715	27,923	84,213
5 26	860	6,703	1,508	9,071
5 27	80,526	152,458	29,185	262,169
5 28	14,492	54,557	39,902	108,951
5 29	9,713	35,470	14,349	59,532
5 30	5,114	40,139	9,265	54,518
5 31	10,167	35,804	5,887	51,858
6 1	1,522	9,258	1,083	11,863
6 2	5,184	14,479	4,123	23,786
6 3	14,816	54,642	22,768	92,226
6 4	13,522	34,047	13,828	61,397
6 5	17,553	32,630	11,598	61,781
6 6	3,311	18,244	6,864	28,419
6 7	6,074	17,761	7,028	30,863
6 8	7,715	18,724	2,874	29,313
6 9	6,278	16,454	10,455	33,187
6 10	6,726	7,084	4,978	18,788
Total	343,571	893,417	418,505	1,655,493
Percent	20.75	53.97	25.28	

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1984.

Date 1/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5 18	982,085	53.90	982,085	839,965	46.10	839,965	1,822,050	1,822,050
5 19	638,715	53.90	1,620,800	546,285	46.10	1,386,250	1,185,000	3,007,051
5 20	915,708	53.90	2,536,509	783,194	46.10	2,169,445	1,698,903	4,705,954
5 21	3,543,357	53.90	6,079,867	3,030,589	46.10	5,200,034	6,573,946	11,279,901
5 22	4,883,832	62.03	10,963,699	2,989,507	37.97	8,189,541	7,873,339	19,153,241
5 23	4,751,558	62.03	15,715,258	2,908,538	37.97	11,098,080	7,660,096	26,813,338
5 24	3,019,851	45.49	18,735,109	3,618,643	54.51	14,716,723	6,638,495	33,451,833
5 25	1,905,467	45.49	20,640,577	2,283,293	54.51	17,000,017	4,188,761	37,640,594
5 26	204,393	49.44	20,844,970	209,023	50.56	17,209,040	413,416	38,054,011
5 27	6,518,250	49.44	27,363,220	6,665,912	50.56	23,874,952	13,184,162	51,238,173
5 28	3,273,399	49.44	30,636,620	3,347,554	50.56	27,222,507	6,620,954	57,859,127
5 29	2,166,975	68.68	32,803,595	987,971	31.31	28,210,478	3,154,946	61,014,074
5 30	2,346,760	68.68	35,150,355	1,069,939	31.31	29,280,418	3,416,699	64,430,774
5 31	1,682,512	54.61	36,832,868	1,398,636	45.39	30,679,054	3,081,149	67,511,923
6 1	360,988	54.61	37,193,856	300,081	45.39	30,979,136	661,069	68,172,993
6 2	652,910	54.61	37,846,767	542,750	45.39	31,521,886	1,195,661	69,368,654
6 3	4,522,863	82.17	42,369,631	981,747	17.84	32,503,634	5,504,611	74,873,265
6 4	3,317,048	82.17	45,686,680	720,009	17.84	33,223,643	4,037,058	78,910,323
6 5	1,936,712	59.60	47,623,393	1,312,805	40.40	34,536,448	3,249,518	82,159,841
6 6	909,976	59.60	48,533,369	616,829	40.40	35,153,278	1,526,806	83,686,648
6 7	843,398	53.21	49,376,768	741,639	46.79	35,894,917	1,585,038	85,271,686
6 8	764,829	53.21	50,141,598	672,550	46.79	36,567,468	1,437,379	86,709,066
6 9	1,101,321	63.02	51,242,919	646,391	36.99	37,213,859	1,747,713	88,456,779
6 10	651,068	63.02	51,893,988	382,127	36.99	37,595,987	1,033,196	89,489,975
Total	51,893,988	57.99		37,595,987	42.01		89,489,975	

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 3. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Kvichak River, Bristol Bay, Alaska, 1984. A dash (-) indicates data not available.

Date 1/	Age I					Age II				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5 19	93	0.7	7.3	0.15	46	104	0.8	9.8	0.20	63
5 20	90	0.3	6.5	0.05	161	100	1.1	8.9	0.27	39
5 21	89	0.7	7.1	0.23	39	102	0.9	10.6	0.25	61
5 22	91	0.3	6.8	0.05	210	106	0.4	10.4	0.12	189
5 23	90	0.2	6.6	0.04	305	102	0.4	9.3	0.11	122
5 24	90	0.2	6.7	0.04	203	102	0.5	9.5	0.12	194
5 25	91	0.3	6.8	0.06	161	105	0.4	10.3	0.10	243
5 26	90	0.6	6.6	0.12	22	108	0.6	10.9	0.17	78
5 27	91	0.3	6.9	0.07	149	104	0.4	10.1	0.10	150
5 28	90	0.2	6.6	0.04	309	102	0.6	9.4	0.16	95
5 29	91	0.3	6.7	0.07	117	107	0.5	10.6	0.12	83
5 30	89	0.3	6.5	0.05	168	104	0.8	10.0	0.21	45
5 31	87	0.4	6.1	0.07	144	107	0.9	10.7	0.21	60
6 1	89	0.4	6.5	0.07	96	105	0.6	10.2	0.15	73
6 2	91	0.5	7.0	0.09	47	103	0.7	9.7	0.16	82
6 3	90	0.3	6.5	0.06	219	104	0.8	9.8	0.20	81
6 4	88	0.2	6.4	0.04	274	102	1.2	9.4	0.28	26
6 5	91	0.3	6.9	0.05	175	102	0.6	9.9	0.16	125
6 6	91	0.4	7.0	0.07	182	106	0.5	10.4	0.13	117
6 7	93	0.3	7.3	0.06	157	105	0.6	10.3	0.16	105
6 8	93	0.6	7.3	0.11	93	105	0.5	10.2	0.13	107
6 9	93	0.2	7.3	0.05	159	103	0.5	9.7	0.13	111
6 10	90	0.4	6.7	0.07	141	102	0.7	9.4	0.17	69
Totals					3,574					2,318
Means	90		6.8			104		10.0		

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 4. Age composition of total migration, mean fork length (mm), and weight (g) by age class, for sockeye salmon smolt, Kvichak River, Bristol Bay, Alaska, 1955-1984. A dash (-) indicates data not available.

Year of Migration	Age I			Age II			Age III			Total Estimate	Reference
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)		
1955	0.07	89	-	0.93	-	-	0.00	-	-	260,068 1/	Paulus and Parker (1974)
1956	0.39	92	-	0.61	116	-	0.00	-	-	77,660 1/	"
1957	0.72	96	7.3	0.28	120	14.4	0.00	-	-	30,907 1/	"
1958	0.98	84	4.6	0.02	114	-	0.00	-	-	3,333,953 1/	"
1959	0.03	80	-	0.97	99	7.6	0.00	-	-	2,863,876 1/	"
1960	0.10	91	6.3	0.90	108	10.3	0.00	-	-	614,003 1/	"
1961	0.72	92	6.8	0.28	117	13.1	0.00	-	-	36,164 1/	"
1962	0.94	82	4.3	0.06	110	9.9	0.00	-	-	1,203,000 1/	"
1963	0.03	83	4.8	0.97	98	7.5	0.00	-	-	4,229,431 1/	Marriott (1965)
1964	0.22	87	5.2	0.78	108	9.8	0.00	-	-	2,061,586 1/	Pennoyer and Seibel (1965)
1965	0.04	90	6.8	0.96	109	11.3	0.00	-	-	1,812,555 1/	Pennoyer (1966)
1966	0.92	94	7.4	0.08	114	12.6	0.00	-	-	275,761 1/	Pennoyer and Stewart (1967)
1967	0.93	86	5.9	0.07	118	14.2	0.00	-	-	3,088,742 1/	Pennoyer and Stewart (1969)
1968	0.11	88	5.5	0.89	104	9.2	0.00	-	-	6,123,683 1/	Paulus and McCurdy (1969)
1969	0.52	92	5.7	0.48	109	10.6	0.00	-	-	1,135,344 1/	McCurdy and Paulus (1972)
1970	0.38	91	6.0	0.62	110	11.0	0.00	-	-	483,638 1/	Paulus and McCurdy (1972)
1971	0.93	90	5.8	0.07	111	11.1	0.00	-	-	91,682,813 2/	Russell (1972)
1972	0.01	80	4.2	0.99	106	10.0	0.00	-	-	54,623,559 2/	Parker (1974a)
1973	0.03	86	5.1	0.97	97	8.3	0.00	-	-	196,966,331 2/	Parker (1974b)
1974	0.09	96	8.3	0.79	111	13.1	0.12	124	17.5	27,082,626 2/	Krasnowski (1975)
1975	0.63	98	8.4	0.37	122	16.4	0.00	-	-	15,632,531 2/	Randall (1976)
1976	0.97	88	5.8	0.03	121	14.2	0.00	-	-	111,388,180 2/	Randall (1977)
1977	0.38	86	5.5	0.62	106	10.1	0.00	-	-	192,578,099 2/	Randall (1978)

-Continued-

Table 4. Age composition of total migration, mean fork length (mm), and weight (g) by age class, for sockeye salmon smolt, Kvichak River, Bristol Bay, Alaska, 1955-1984. A dash (-) indicates data not available (continued).

Year of Migration	Age I			Age II			Age III			Total Estimate	Reference
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)		
1978	0.12	88	6.0	0.88	97	7.8	0.00	-	-	245,591,014 2/	Yuen (1980a)
1979	0.51	90	6.0	0.49	109	10.3	0.00	-	-	55,181,540 2/	Yuen (1980b)
1980	0.94	88	5.9	0.06	110	10.7	0.00	-	-	192,853,007 2/	Bergstrom and Yuen (1981)
1981	0.89	85	5.4	0.11	108	10.2	0.00	-	-	252,222,769 2/	Yuen and Wise (1982)
1982	0.58	84	5.1	0.39	103	9.1	0.00	-	-	239,721,729 2/	Bill (1984)
1983	0.08	80	4.9	0.92	98	8.5	0.00	-	-	82,793,899 2/	Bill et al. (in press)
		—	—		—	—					
	Mean	88	5.7		109	10.8					
1984	0.58	90	6.8	0.42	104	10.0	0.00			89,489,975	

1/ Estimates of smolt numbers based upon fyke net sampling

2/ Estimates of smolt numbers based upon sonar techniques

Table 5. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1956-1982 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
<u>Estimates of smolt numbers based upon fyke net sampling</u>						
1956	9,443,318	3,267,274 (54)	2,777,960 (46)	0	6,045,234	0.640
1957	2,842,810	85,916 (13)	552,603 (87)	0	638,519	0.225
1958	534,785	61,400 (86)	10,126 (14)	0	71,526	0.134
1959	680,000	26,038 (27)	72,180 (73)	0	98,218	0.144
1960	14,630,000	1,130,820 (22)	4,116,093 (78)	0	5,246,913	0.359
1961	3,705,849	113,338 (7)	1,603,464 (93)	0	1,716,802	0.463
1962	2,580,884	458,122 (21)	1,748,178 (79)	0	2,206,300	0.855
1963	338,760	64,377 (73)	23,377 (27)	0	87,754	0.259
1964	957,120	252,384 (53)	222,528 (47)	0	474,912	0.496
1965	24,325,926	2,866,214 (34)	5,475,362 (66)	0	8,341,576	0.343
1966	3,775,184	648,321 (55)	541,017 (45)	0	1,189,338	0.315
1967	3,216,208	594,327 (67)	298,282 (33)	0	892,609	0.278
1968	2,557,440	185,356				
<u>Estimates of smolt numbers based upon sonar equipment</u>						
1968			5,959,383	0	-	-
1969	8,394,204	85,723,430 (61)	54,159,340 (39)	0	139,882,770	16.664
1970	13,935,306	464,219 (<1)	191,842,930 (98)	2,918,768 (1)	195,225,917	14.009
1971	2,387,392	5,123,400 (19)	21,423,246 (81)	0	26,546,646	11.120
1972	1,009,962	2,740,610	-	-	-	-
1973	226,554	-	3,031,287	0	-	-
1974	4,433,844	108,356,892 (49)	114,269,848 (51)	0	222,626,740	50.211
1975	13,140,450	78,308,251 (27)	213,364,470 (73)	0	291,672,721	22.197

-Continued-

Table 5. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1956-1982 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available (continued).

Brood Year	Total Spawning Escapement	Number of Smolt Produced					Per Spawner
		Age I	Age II	Age III	Total		
<u>Estimates of smolt numbers based upon sonar equipment</u> (continued)							
1976	1,965,282	32,226,544 (55)	26,423,348 (45)	0	58,649,892	29.843	
1977	1,341,144	28,758,191 (73)	10,410,467 (27)	0	39,168,658	29.205	
1978	4,149,288	182,442,540 (85)	32,294,536 (15)	0	214,737,076	51.753	
1979	11,218,434	219,928,232 (71)	89,300,703 (29)	0	309,228,935	27.564	
1980	17,505,268	150,421,026 (62)	76,244,773 (38)	0	199,172,858	12.948	
1981	1,754,358	6,549,125 (15)	37,595,987 (85)		44,145,112	25.163	
1982	1,134,840	51,893,988					

Table 6. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1952-1982 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total 1/ Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult 1/ Returns	Adult Returns per Smolt	Number of Smolt	Adult 1/ Returns	Adult Returns per Smolt
<u>Estimates of smolt numbers based upon fyke net sampling</u>							
1952	-	-	17,442,177	-	241,870	3,568,683	14.75
1953	-	18,198	150,000	8.24	47,373	416,438	8.79
1954	-	30,287	108,062	3.57	8,654	638,807	73.82
1955	-	22,253	349,379	15.70	66,679	1,111,184	16.66
1956	9,443,318	3,267,274	31,072,719	9.51	2,777,960	7,669,165	2.76
1957	2,842,810	85,916	477,643	5.56	552,603	3,492,512	6.32
1958	534,785	61,400	121,131	1.97	10,126	157,830	15.59
1959	680,000	26,038	321,845	12.36	72,180	212,080	2.94
1960	14,630,000	1,130,820	1,841,471	1.63	4,116,093	52,434,234	12.74
1961	3,705,849	113,338	513,865	4.53	1,603,464	2,888,592	1.80
1962	2,580,884	458,122	249,330	0.54	1,748,178	4,951,714	2.83
1963	338,760	64,377	94,415	1.47	23,377	918,394	39.29
1964	957,120	252,384	2,447,045	9.70	222,528	2,918,799	13.12
1965	24,325,926	2,866,214	10,090,601	3.52	5,475,362	32,942,281	6.02
1966	3,775,184	648,321	1,534,238	2.37	541,017	4,488,399	8.30
1967	3,216,208	594,327	572,694	0.96	298,282	829,337	2.78
1968	2,557,440	185,356	300,402	1.62	-	-	-
<u>Estimates of smolt numbers based upon sonar equipment</u>							
1968	-	-	-	-	5,959,383	206,095	0.03
1969	8,394,204	85,723,430	442,515	0.01	54,159,340	4,787,896	0.09

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Table 6. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1952-1982 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available. (continued).

Brood Year	Total 1/ Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult 1/ Returns	Adult Returns per Smolt	Number of Smolt	Adult 1/ Returns	Adult Returns per Smolt
<u>Estimates of smolt numbers based upon sonar equipment</u>							
1970	13,935,306	464,219	55,624	0.12	191,842,930	15,152,302	0.08
1971	2,387,392	5,123,400	332,822	0.06	21,423,246	2,412,403	0.11
1972	1,009,962	2,740,610	404,693	0.15	-	1,468,546	0.25
1973	226,554	-	1,566,472	0.16	3,031,287	802,035	0.26
1974	4,433,844	108,356,892	8,158,273	0.08	114,269,848	17,127,032	0.15
1975	13,140,450	78,308,251	6,735,383	0.09	213,364,470	28,823,894	0.14
1976	1,965,282	32,226,544	5,847,020	0.18	26,423,348	4,012,457	0.15
1977	1,341,144	28,758,191	2,451,387	0.09	10,410,467	281,173	0.03
1978	4,149,288	182,442,540	2,895,181	0.02	32,294,536	1,956,845	0.06
1979	11,218,434	219,928,232	18,460,313	0.08 2/	89,300,703	17,699,284	0.20 2/
1980	22,505,268	150,421,026	2,924,455	0.02 2/	76,244,773		
1981	1,754,358	6,549,125			37,595,987		
1982	1,134,840	51,893,988					

1/ Yuen et al. (1986).

2/ Future adult returns will increase these values.

Table 7. Climatological and hydrological observations made at sockeye salmon smolt counting site, Kvichak River, Bristol Bay, Alaska, 1984.
A dash (-) indicates missing data.

Date	Cloud Cover 1/		Wind Velocity (km/hr)		Air Temp. (C)		Mean Water Temp. (C)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr	Min	Max		
5 19	2	4	calm	calm	1.1	8.9	5.5	clear
5 20	4	2	calm	5 NE	6.7	27.8	6.5	clear
5 21	4	3	5 NE	10 NE	3.9	26.7	6.3	clear
5 22	4	3	calm	5 NE	5.0	-	6.5	clear
5 23	5	2	calm	15 SW	0.0	20.0	7.3	clear
5 24	3	3	2 S	15 SW	5.0	22.2	7.3	clear
5 25	4	2	calm	10 SE	5.0	26.7	7.3	clear
5 26	5	4	calm	5 SE	0.0	21.7	7.3	clear
5 27	4	2	5 NE	15 SW	1.1	20.6	6.8	clear
5 28	1	3	calm	20 SW	-0.6	26.7	7.6	clear
5 29	4	3	- -	calm	3.3	22.2	7.3	clear
5 30	4	2	15 SW	5 S	3.9	21.1	6.8	clear
5 31	1	1	calm	5 S	-3.3	22.2	7.6	clear
6 1	1	1	5 SW	10 NE	3.9	21.7	8.0	clear
6 2	1	1	5 SW	20 SW	0.6	23.3	8.8	clear
6 3	1	2	10 NE	20 SW	3.3	23.3	8.8	clear
6 4	1	3	15 SW	20 SW	7.8	23.3	8.9	clear
6 5	2	2	5 SW	20 SW	4.4	22.2	8.8	clear
6 6	5	3	5 SW	15 NE	5.0	20.0	8.9	clear
6 7	4	3	15 SW	5 NE	6.7	16.7	8.5	clear
6 8	4	2	10 NE	20 E	3.9	21.1	9.0	clear
6 9	3	3	15 NE	10 E	3.3	23.3	9.5	clear
6 10	3	2	15 NE	10 E	6.7	21.1	10.0	clear
6 11	2	-	10 E	- -	-	-	9.5	clear

1/ 1 = cloud cover not more than 1/10
 2 = cloud cover not more than 1/2
 3 = cloud cover more than 1/2
 4 = completely overcast
 5 = fog

Table 8. Water temperatures at sockeye salmon smolt counting site, Kvichak River, Bristol Bay, Alaska, 1963-1984.
A dash (-) indicates data not available.

Year	Sample Period	Water Temperature (C)			Reference
		Minimum	Maximum	Mean	
1963	16 May-14 June	2.2	8.9	5.5	Marriott (1965)
1964	18 May-14 June	0.0	5.6	2.6	Pennoyer and Seibel (1965)
1965	17 May-11 June	0.0	8.9	4.4	Pennoyer (1966)
1966	16 May-26 June	0.0	11.1	4.7	Pennoyer and Stewart (1967)
1967	17 May-20 June	1.1	9.4	6.9	Pennoyer and Stewart (1969)
1968	12 May-12 June	3.3	8.3	5.4	Paulus and McCurdy (1969)
1969	16 May-18 June	0.3	7.8	3.9	McCurdy and Paulus (1972)
1970	13 May- 7 June	2.8	11.1	6.8	Paulus and McCurdy (1972)
1971	17 May-20 June	1.1	3.3	2.4	Russell (1972)
1972	18 May-18 June	0.6	5.0	2.9	Parker (1974a)
1973	15 May-14 June	2.9	8.9	4.9	Parker (1974b)
1974	13 May- 9 June	3.0	8.0	6.2	Krasnowski (1975)
1975	17 May-15 June	2.0	8.0	3.8	Randall (1976)
1976	18 May-19 June	2.0	9.5	3.9	Randall (1977)
1977	17 May-14 June	3.0	9.5	6.4	Randall (1978)
1978	19 May- 9 June	5.0	11.0	7.6	Yuen (1980a)
1979	1-10 June	8.0	10.0	8.6	Yuen (1980b)
1980	16 May-18 June	1.5	9.0	5.5	Bergstrom and Yuen (1981)
1981	15 May- 9 June	7.0	10.0	8.2	Yuen and Wise (1982)
1982	14 May-15 June	2.5	8.5	4.9	Bill (1984)
1983	19 May-14 June	5.2	10.5	7.9	Bill et al. (in press)
Mean		2.5	8.7	5.4	
1984	19 May-11 June	5.5	10.0	7.9	

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1984 NAKNEK, EGEGIK, AND UGASHIK RIVERS SOCKEYE SALMON SMOLT STUDIES

By

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INTRODUCTION

Programs to sample and count seaward migrating sockeye salmon (*Oncorhynchus nerka*) smolt provide data which are used to forecast adult returns and estimate optimal spawning escapement levels. Initial data were collected by the United States Fish and Wildlife Service (USFWS) using fyke nets. Such studies were done on the Ugashik River system during 1955-1962 (with University of Washington, Fisheries Research Institute, personnel conducting Ugashik River smolt studies in 1955 and 1957), and on the Naknek River system during 1956-1965. The Alaska Department of Fish and Game (ADF&G) assumed responsibility for Bristol Bay sockeye salmon smolt studies during the 1960s and continued using fyke nets on the Ugashik River during 1963-1965, 1967-1970, and 1972-1975, and on the Naknek River during 1966-1977.

Fyke net fishing, however, proved to be a poor method for estimating smolt numbers. Net avoidance could not be quantified and large numbers of smolt were killed during capture and handling. Therefore, field testing of sonar equipment, developed by Bendix Corporation under a contract to ADF&G, to count smolt was begun in 1970 on the Kvichak River (McCurdy 1972b; Paulus and McCurdy 1972; Paulus and Parker 1974). Sonar gear was tested on the Ugashik River during 1973-1975 (Schroeder 1974b and 1975; Sanders 1976). Although results were promising, budgetary constraints limited subsequent smolt studies on this river, as well as on the Naknek and Egegik Rivers, to occasional fyke net sampling to obtain age and size data (Ugashik River, 1977, 1978, and 1982; Naknek River, 1978; Egegik River, 1977 and 1978) (Huttunen 1980; Eggers 1984). An experimental, 2-array system was tested on the Egegik River during the spring of 1981 (Bue 1982) and was replaced with the present counter in 1982 (Bue 1984). Smolt sonar projects were established on the Naknek River in 1982 (Huttunen 1984), and the Ugashik River in 1984.

Objectives of the 1984 Naknek, Egegik, and Ugashik River systems sockeye salmon smolt studies were: 1) to estimate seaward migrating sockeye salmon smolt numbers, 2) to describe smolt migration patterns, 3) to collect age, weight, and length data for smolt, and 4) to record climatological and hydrological parameters which might affect migratory behavior.

MATERIALS AND METHODS

Sonar counting equipment was used to count smolt migrating to sea past field sites on the Naknek, Egegik, and Ugashik Rivers. The equipment used consisted of either two or three 3.05 m (10 ft) long ladder-shaped arrays, which were anchored underwater at the counting site, and a control unit, which was housed on shore in a canvas wall tent. Each array housed 10 upward-facing transducers and monitored about 3.35 m (11 ft) of river width. Three arrays were placed in the Naknek River, about 13 km (7.8 miles) below the outlet of Naknek Lake, and anchored 17, 39, and 67 m (56, 129, and 221 ft) from the east shore at the counting site. Three arrays were placed in the Egegik River, about 4 km (2.4 miles) below the outlet of Becharof Lake, and anchored 38, 53, and 64 m (125, 175, and 211 ft) from the west shore at the counting site. Only two arrays were placed in the Ugashik River at the outlet of Lower Ugashik Lake, and anchored 11 and 15 m (36 and 50 ft) from the south shore at the counting site. Installation of all sonar arrays closely followed procedures described by Randall (1977).

The control unit automatically printed counts from all arrays every hour, and could also be set to print counts at 7-1/2, 15, or 30 minute intervals. A maximum of 19,999 counts could be accumulated by the counter before the specified printing interval was reached. If a greater number of counts was registered before this, the internal counter was set to zero and began counting from one. Therefore, the sonar system was monitored continuously throughout the season so that the number of times this occurred within each printing interval was known. Also, corrections sometimes had to be made for false counts due to drifting ice, heavy rain, wind, boat traffic, etc., and for changes in river depth or current speed.

Sonar signal pulse rate was increased as river current speed increased, since current speed determined the time required for smolt to pass through the sonar beams. Current speed measurements were obtained from a meter anchored directly behind each inshore array. Since river current speed at the Naknek and Egegik sites was affected by tide, sonar pulse rate sometimes had to be adjusted every 15 or 30 minutes. Since pulse rate could not be varied among arrays, current measurements were periodically made during the season behind the other arrays to estimate corrections for current speed differences between these and the inshore array. Current speed was greatest over the inshore array at both the Naknek and Ugashik sites, but was greatest over the center array at the Egegik site (Naknek River mean speed: inshore, 1.24 m/s [4.08 ft/s]; center, 1.15 m/s [3.80 ft/s]; offshore, 0.78 m/s [2.56 ft/s]; Egegik River mean speeds: inshore, 0.60 m/s [1.98 ft/s]; center, 0.73 m/s [2.41 ft/s]; offshore, 0.72 m/s [2.38 ft/s]; Ugashik River mean speeds: inshore, 2.31 m/s [7.62 ft/s]; offshore, 2.22 m/s [7.31 ft/s]). Therefore, Naknek River center and offshore array counts were multiplied by 0.93 and 0.63, respectively, Egegik River center and offshore counts were multiplied by 1.21 and 1.20, respectively, and Ugashik River offshore counts were multiplied by 0.96.

Total hourly counts were calculated for each array by subtracting false counts, linearly interpolating counts during missed time period (i.e.,

periods when the counter was manually disabled to avoid making false counts or periods when the counter was inoperative) and multiplying these counts by a current speed correction factor. Hourly counts were then expanded to account for smolt which migrated through sections of the river not covered by the arrays. The expansion factor used was the inverse of the estimated proportion of the total smolt migration path which was sampled by the arrays. The area of the total smolt migration path was estimated from data on 1) smolt distribution across the river at the counting site, obtained with a side scanning sonar unit, and 2) river depths across the counting site transect.

Estimates of total daily smolt migration past counting sites were made by summing adjusted total hourly counts and multiplying results by the actual number of smolt required to generate a single sonar count. All sonar systems were calibrated, at the factor, to register one count for the biomass equivalent of 41.49875 g. Therefore, pooled mean weight of all salmonid smolt from daily fyke net samples was used to estimate actual number of smolt equivalent to one sonar count (i.e., number per count = 41.49875 g/pooled mean weight).

Fyke net catches were also used to apportion daily smolt counts according to age class and salmonid species. Samples of at least 400 sockeye salmon smolt were used to estimate age class composition for each 24-hour sampling period. If this number of smolt was not captured during a 24-hour period, samples from subsequent periods were combined until a total of at least 400 smolt was obtained. Samples of 400 smolt produced estimates of the actual proportion of age I or age II smolt which were within 0.05 of the estimated proportion (at the 0.05 significance level) for actual age class proportions ranging from 0.95 to 0.05 (Appendix B in Bill et al. in press). Samples of this size also produced estimates of the actual number of either age I or II smolt which were within 50% of the estimated number (at the 0.05 significance level) for actual age class proportions ranging from 0.05 to 0.20, and which were within 15% of the estimated number (at the 0.05 significance level) for actual age class proportions ranging from 0.30 to 0.95.

Age, weight, and length sampling is very time consuming for smolt, consequently, the sampling procedures were streamlined. Scale samples, weights, and fork lengths were obtained from about 100 smolt each day. An additional 300 smolt were measured for length data, but were not weighed or used for scale samples. After the field season, smolt for which only length measurements had been obtained were assigned a weight and an age based upon analysis of available age, weight, and length data (Appendix C in Bill et al. 1986).

A 1.2 m by 1.8 m (4 ft by 6 ft) fyke net was used to capture smolt for samples. Initially, sampling was attempted at 0600, 1200, 1800, and 2400 h each day. However, few smolt were caught between 0600 and 2400 h, and all sampling effort was shifted to the period between 2400 and 0500 h.

RESULTS AND DISCUSSION

Naknek River

A total of 3,075,514 sonar counts were recorded during the 1984 season, 19 May through 5 July (Table 1). Approximately 16% of these counts were registered over the inshore array, 35% over the center array, and 49% over the offshore array. Most smolt migration across the counting site transect occurred from the east bank of the river to a point 73 m (240 ft) offshore.

The final sockeye salmon smolt population size estimate was 81,559,941 (Table 2). Age composition of the total population was 39% age I (1982 brood year), 60% age II (1981 brood year), and less than 0.1% age III (1980 brood year). Since age II and III smolt were usually larger and tended to migrate to sea earlier in the season than age I smolt, numbers of smolt per sonar count increased as the season progressed (range, 3.0 to 5.2 smolt per count) (Tables 2 and 3).

A total of 3,027 sockeye salmon smolt was sampled for age, weight, and length information (Table 4). Mean weights of age I, II, and III smolt were 8.8, 11.4, and 16.7 g, respectively. Mean lengths of age I, II, and III smolt were 997, 108, and 124 mm, respectively. Mean lengths of age I and II smolt were less than the grand mean for past years. Mean weight of age I was slightly higher than historically observed as was mean length and weight of age III smolt (1957-1982: age I smolt length and weight, 100 mm and 8.3 g, respectively; age II smolt length and weight, 112 mm and 12.6 g, respectively; age III smolt length and weight, 121 mm and 15.9 g, respectively) (Table 5).

Weather and river conditions were recorded at the sonar site during 19 May through 6 July (Table 6). Mean air and water temperatures during this period were 12.0°C (range, -5.0-26.0°C) and 13.0°C (range, 7.5-16.0°C), respectively. Mean water temperature during past seasons was generally lower than that recorded during 1984 (1967-1982; mean, 10.6°C; range, 6.8-14.1°C) (Table 7).

Egegik River

A total of 1,990,336 sonar counts were recorded during the 1984 season, 19 May through 10 June (Table 8). Nine percent of these count were registered over the inshore array, 31% over the center array, and 60% over the offshore array. Most smolt migration across the counting site transect occurred within the area 3 m to 88 m offshore of the west bank.

The final sockeye salmon smolt population size estimate was 49,667,432 (Table 9). Age composition was estimated to be 35% age I (1982 brood year), 65% age II (1981 brood year), and less than 0.5% age III (1980 brood year). An estimated 474,781 coho salmon were also enumerated. The larger smolt tended to migrate later in the season, consequently, numbers of smolt per count decreased as the season progressed (range 2.9 to 3.5 smolt per count) (Table 10).

Table 1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Naknek River, Bristol Bay, Alaska, 1984. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Sonar Counts				
Transducer Array				
Date 1/	Inshore	Center	Offshore	Total
5 19	2,560	1,849	1,137	5,546
5 20	2,849	1,708	566	5,123
5 21	607	897	1,187	2,691
5 22	4,756	7,128	9,487	21,371
5 23	3,796	9,608	15,831	29,235
5 24	5,103	8,970	10,831	24,904
5 25	11,639	67,935	78,651	158,225
5 26	9,944	46,398	46,684	103,026
5 27	10,128	48,140	61,863	120,131
5 28	8,409	27,861	54,149	90,419
5 29	8,829	134,564	103,734	247,127
5 30	9,950	11,725	54,188	75,863
5 31	9,293	32,196	9,479	50,968
6 1	108,948	41,121	65,189	215,258
6 2	7,713	17,403	27,141	52,257
6 3	9,962	34,224	80,854	125,040
6 4	7,969	49,046	170,338	227,353
6 5	7,116	32,406	67,016	106,538
6 6	28,069	49,129	105,544	182,742
6 7	30,564	54,776	120,885	206,225
6 8	22,968	34,730	77,829	135,527
6 9	17,463	61,078	63,933	142,474
6 10	14,172	42,242	44,724	101,138
6 11	12,303	26,675	22,063	61,041
6 12	10,986	14,563	21,366	46,915
6 13	13,706	16,898	14,803	45,407
6 14	11,708	13,878	21,165	46,751
6 15	5,059	4,272	4,109	13,440
6 16	8,598	10,507	6,309	25,414
6 17	1,810	1,294	732	3,836
6 18	1,547	432	560	2,539
6 19	2,710	2,675	1,192	6,577
6 20	5,206	1,903	1,844	8,953
6 21	5,021	3,583	6,283	14,887
6 22	7,165	8,862	11,755	27,782
6 23	7,090	12,712	10,314	30,116

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Table 1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Naknek River, Bristol Bay, Alaska, 1984. False counts were deleted, and interpolations were made for time missed when sonar not operated (continued).

Sonar Counts				
Transducer Array				
Date 1/	Inshore	Center	Offshore	Total
6 24	9,454	50,680	34,886	95,020
6 25	5,428	38,040	17,123	60,591
6 26	5,544	9,977	13,744	29,265
6 27	12,912	15,081	13,805	41,798
6 28	10,424	4,255	3,416	18,095
6 29	3,204	7,450	2,103	12,757
6 30	2,457	2,211	1,613	6,281
7 1	5,022	5,705	2,178	12,905
7 2	5,192	2,487	1,722	9,401
7 3	4,565	4,420	4,226	13,211
7 4	1,874	1,950	2,236	6,060
7 5	1,996	3,229	2,066	7,291
Total	503,788	1,078,873	1,492,853	3,075,514
Percent	16.38	35.08	48.54	

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Naknek River, Bristol Bay, Alaska, 1984.

		Age I		Age II		Age III		All Ages	
Date	1/	Number	Percent	Number	Percent	Number	Percent	Daily Total	Cumulative Total
5	19	4,984	4.64	102,433	95.36	0		107,417	107,417
5	20	4,588	4.64	94,305	95.36	0		98,893	206,311
5	21	2,438	4.64	50,115	95.36	0		52,554	258,865
5	22	19,368	4.64	398,061	95.36	0		417,429	676,295
5	23	27,112	4.64	557,204	95.36	0		584,316	1,260,612
5	24	24,927	4.64	512,313	95.36	0		537,241	1,797,853
5	25	174,196	4.64	3,580,029	95.36	0		3,754,225	5,552,079
5	26	114,375	4.64	2,350,622	95.36	0		2,464,998	8,017,077
5	27	124,982	4.64	2,568,608	95.36	0		2,693,591	10,710,668
5	28	355,377	16.08	1,809,274	81.84	46,057	2.08	2,210,708	12,921,377
5	29	826,478	16.08	4,207,715	81.84	107,112	2.08	5,141,307	18,062,684
5	30	232,596	16.08	1,184,182	81.84	30,144	2.08	1,446,924	19,509,609
5	31	195,024	16.08	992,895	81.84	25,275	2.08	1,213,195	20,722,805
6	1	717,656	16.08	3,653,684	81.84	93,008	2.08	4,464,349	25,187,154
6	2	197,515	16.08	1,005,580	81.84	25,598	2.08	1,228,694	26,415,849
6	3	1,208,949	33.79	2,363,873	66.07	5,008	0.14	3,577,831	29,993,680
6	4	2,026,825	33.79	3,963,077	66.07	8,397	0.14	5,998,300	35,991,981
6	5	1,014,616	33.79	1,983,891	66.07	4,203	0.14	3,002,712	38,994,693
6	6	1,723,905	33.79	3,370,772	66.07	7,142	0.14	5,101,820	44,096,514
6	7	2,613,469	47.85	2,783,604	50.97	64,722	1.18	5,461,796	49,558,310
6	8	1,619,580	47.85	1,725,014	50.97	40,108	1.18	3,384,703	52,943,014
6	9	2,332,770	47.85	2,484,632	50.97	57,770	1.18	4,875,174	57,818,188
6	10	1,635,443	47.85	1,741,910	50.97	40,501	1.18	3,417,855	61,236,044
6	11	883,559	47.85	941,078	50.97	21,881	1.18	1,846,519	63,082,564
6	12	725,387	47.85	772,610	50.97	17,964	1.18	1,515,962	64,598,526
6	13	1,201,866	73.71	428,667	26.29	0		1,630,533	66,229,060
6	14	1,149,928	73.71	410,142	26.29	0		1,560,071	67,789,131

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Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Naknek River, Bristol Bay, Alaska, 1984 (continued).

Date 1/	Age I		Age II		Age III		All Ages	
	Number	Percent	Number	Percent	Number	Percent	Daily Total	Cumulative Total
6 15	295,551	73.71	105,413	26.29	0		400,964	68,190,096
6 16	587,873	73.71	209,675	26.29	0		797,549	68,987,646
6 17	84,853	73.71	30,264	26.29	0		115,117	69,102,764
6 18	53,577	73.71	19,109	26.29	0		72,687	69,175,452
6 19	144,709	73.71	51,613	26.29	0		196,322	69,371,774
6 20	191,858	73.71	68,429	26.29	0		260,288	69,632,062
6 21	326,153	73.71	116,328	26.29	0		442,481	70,074,544
6 22	622,791	73.71	222,130	26.29	0		844,922	70,919,466
6 23	693,629	73.71	247,395	26.29	0		941,024	71,860,490
6 24	2,123,094	73.71	757,240	26.29	0		2,880,334	74,740,825
6 25	1,837,608	86.15	295,363	13.85	0		2,132,972	76,873,797
6 26	843,087	86.15	135,511	13.85	0		978,598	77,852,396
6 27	1,134,445	86.15	182,342	13.85	0		1,316,787	79,169,183
6 28	454,769	86.15	73,096	13.85	0		527,865	79,697,049
6 29	315,450	85.22	54,691	14.78	0		370,142	80,067,191
6 30	143,574	85.22	24,892	14.78	0		168,466	80,235,657
7 1	316,812	85.22	54,927	14.78	0		371,739	80,607,397
7 2	222,873	85.22	38,640	14.78	0		261,513	80,868,910
7 3	287,900	85.22	49,914	14.78	0		337,814	81,206,725
7 4	132,699	85.22	23,006	14.78	0		155,706	81,362,431
7 5	168,325	85.22	29,183	14.78	0		197,509	81,559,941
Total	32,139,569	39.41	48,825,473	59.86	594,898	0.73	81,559,941	

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Naknek River, Bristol Bay, Alaska, 1984.

Date 1/	Mean Weight of Smolt (g)	Smolt per Count
5 19	no sample	5.0
5 20	no sample	5.0
5 21	no sample	5.0
5 22	13.8	3.0
5 23	13.6	3.0
5 24	no sample	5.0
5 25	11.6	3.6
5 26	11.6	3.6
5 27	12.3	3.4
5 28	11.0	3.8
5 29	13.6	3.0
5 30	13.0	3.2
5 31	12.1	3.4
6 1	12.5	3.3
6 2	11.5	3.6
6 3	9.4	4.4
6 4	10.1	4.1
6 5	9.6	4.3
6 6	9.6	4.3
6 7	11.0	3.8
6 8	10.7	3.9
6 9	8.1	5.1
6 10	8.2	5.1
6 11	9.1	4.6
6 12	8.3	5.0
6 13	7.6	5.5
6 14	8.0	5.2
6 15	9.0	4.6
6 16	8.7	4.8
6 17	no sample	5.0
6 18	no sample	5.0
6 19	9.1	4.6
6 20	no sample	5.0
6 21	no sample	5.0
6 22	no sample	5.0
6 23	8.8	4.7
6 24	9.3	4.5
6 25	8.2	5.1
6 26	8.1	5.1
6 27	8.6	4.8
6 29	9.0	4.6
6 30	9.8	4.2

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Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Naknek River, Bristol Bay, Alaska, 1984 (continued).

Date 1/	Mean Weight of Smolt (g)	Smolt per Count
7 1	10.0	4.1
7 2	9.5	4.4
7 3	9.5	4.4
7 4	10.5	3.9
7 5	10.5	3.9

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Naknek River, Bristol Bay, Alaska, 1984. A dash (-) indicates data not available.

Date 1/	Age I					Age II					Age III				
	Mean		Mean		Sample	Mean		Mean		Sample	Mean		Mean		Sample
	Length	Std. Error	Weight	Std. Error		Length	Std. Error	Weight	Std. Error		Length	Std. Error	Weight	Std. Error	
	(mm)		(g)		Size	(mm)		(g)		Size	(mm)		(g)		Size
5 22						117	1.1	13.8	0.3	30					
5 23	105		11.9		1	114	0.7	13.6	0.2	68					
5 25	104	1.9	10.7	0.5	9	110	0.6	11.8	0.2	111					
5 26	102	1.5	10.2	0.4	19	110	0.6	11.9	0.2	101					
5 27	100	1.6	10.1	0.4	15	110	0.7	12.6	0.2	105					
5 28	98	2.5	9.5	0.6	19	108	1.3	11.7	0.4	41					
5 29	97	2.8	8.8	0.8	8	116	1.1	14.3	0.4	51	124		18.0		1
5 30	107	1.0	11.6	0.4	6	112	0.8	13.2	0.2	54					
5 31	96	1.7	9.4	0.5	25	110	0.8	12.6	0.6	92	128	3.3	18.2	1.5	3
6 1	106	6.3	10.9	1.7	3	111	0.7	12.2	0.2	52	124	1.5	16.3	0.8	5
6 2	97	1.8	9.1	0.6	15	108	0.7	12.0	0.2	81					
6 3	94	1.6	7.7	0.4	14	103	1.3	10.3	0.4	26					
6 4	93	0.9	8.0	0.2	46	106	0.6	10.9	0.2	111					
6 5	96	1.1	8.2	0.3	30	106	0.7	10.4	0.2	48					
6 6	94	0.7	7.8	0.2	58	104	0.7	10.4	0.2	120	122		14.4		1
6 8	95	1.1	7.9	0.3	29	109	0.8	11.1	0.2	97	128	1.4	17.2	0.5	6
6 9	92	0.6	7.4	0.2	45	103	1.6	10.2	0.4	14					
6 10	91	1.1	6.9	0.2	36	106	1.7	10.1	0.5	24					
6 11	97	1.4	8.4	0.3	28	105	1.3	9.8	0.3	32					
6 12	92	0.6	7.2	0.2	66	102	1.2	9.6	0.3	54					
6 13	90	0.6	6.8	0.2	29	104	3.6	9.6	0.9	11					
6 14	96	0.9	7.9	0.2	33	100	4.1	8.8	0.8	7					
6 15	92	1.0	7.2	0.2	22	108	1.8	11.2	0.5	18					
6 16	92	1.4	7.9	0.3	31	106	2.2	11.5	0.6	9					
6 19	97	1.9	8.2	0.4	12	110	3.8	11.4	1.2	5					

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Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Naknek River, Bristol Bay, Alaska, 1984. A dash (-) indicates data not available (continued).

Date 1/	Age I					Age II					Age III				
	Mean		Mean		Sample	Mean		Mean		Sample	Mean		Mean		Sample
	Length	Std.	Weight	Std.		Length	Std.	Weight	Std.		Length	Std.	Weight	Std.	
	(mm)	Error	(g)	Error	Size	(mm)	Error	(g)	Error	Size	(mm)	Error	(g)	Error	Size
6 23	95	0.5	8.3	0.1	120	107	1.5	10.6	0.4	30					
6 24	97	0.5	8.4	0.2	82	109	1.3	11.3	0.4	38					
6 25	94	0.6	7.9	0.1	94	101	1.6	9.2	0.4	25					
6 26	92	0.5	7.9	0.1	107	99	2.0	9.3	0.5	12					
6 27	93	0.3	8.5	0.1	109	102	2.3	10.4	0.5	9					
6 28	94	0.5	8.7	0.1	100	101	2.2	10.2	0.6	20					
6 29	95	1.1	9.3	0.3	24	104	3.8	12.1	1.1	5					
6 30	96	0.5	9.6	0.2	88	106	2.1	12.3	0.7	17					
7 1	94	0.9	9.1	0.3	27	114	5.2	13.2	0.7	3					
7 2	97	0.5	9.3	0.2	48	100	2.1	10.0	0.6	12					
7 3	98	1.0	10.1	0.2	21	106	2.5	11.5	0.8	9					
7 4	97	1.1	10.4	0.4	18	102	5.0	11.0	1.7	2					
7 5	97	0.7	10.2	0.3	30										
Totals					1,467					1,544					16
Means	97		8.8			108		11.4			124		16.7		

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 5. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Naknek River, Bristol Bay, Alaska, 1957-1984. A dash (-) indicates data not available.

Year	Sample Migration	Sample Dates	Sample Size	Age I		Age II		Age III		Reference
				Mean Length	Mean Weight	Mean Length	Mean Weight	Mean Length	Mean Weight	
1957	-	-	-	111	13.1	112	13.1	-	-	USF&WS (unpublished)
1958	-	-	-	91	6.9	114	11.3	-	-	"
1959	-	-	-	97	8.2	106	10.1	-	-	"
1960	-	-	-	99	8.8	109	11.9	-	-	"
1961	-	-	-	103	10.8	113	13.8	-	-	"
1962	-	-	-	105	10.4	112	12.5	-	-	"
1963	-	-	-	98	8.1	114	12.8	-	-	"
1964	-	-	-	97	7.7	110	11.0	-	-	"
1965	-	-	-	99	8.4	114	13.0	-	-	"
1966	31 May-13 July	933	106	10.6	118	14.2	-	-	-	Robertson (1967)
1967	27 May- 9 July	855	113	13.1	119	14.7	-	-	-	Van Valin (1969a)
1968	23 May-12 August	1,380	99	8.4	108	11.1	-	-	-	Van Valin (1969b)
1969	30 May-27 June	1,079	100	7.5	112	12.1	-	-	-	Siedelman (1972)
1970	29 May- 5 July	932	100	9.0	114	12.1	-	-	-	Biver (1972)
1971	6 June-7 July	-	102	8.8	120	13.5	-	-	-	McCurdy (1972a)
1972	8 June-6 July	689	98	9.1	110	11.9	-	-	-	McCurdy (1974a)
1973	28 May-26 June	745	106	10.7	114	12.9	122	15.2	-	McCurdy (1974b)
1974	22 May-27 June	827	104	10.3	118	14.5	109	11.3	-	Bill (1975)
1975	28 May- 9 July	1,037	98	8.3	111	12.1	109	11.5	-	Bill (1976)
1976	22 May-26 June	833	91	7.2	107	13.4	131	2.2	-	Bill (1977)
1977	20 May-23 June	1,178	92	7.2	113	11.9	-	-	-	Yuen (1978)
1978	1 June	239	96	8.3	105	11.0	-	-	-	Huttenun (1980)
1982	24 May-10 July	3,222	94	8.0	100	14.7	-	-	-	Huttenun (1984)
1983	17 May- 5 July	2,480	94	8.0	110	12.2	133	19.1	-	Fried and Yuen (in press)
Mean				100	8.3	112	12.6	121	15.9	
1984	22 May- 5 July	3,011	97	8.8	108	11.4	124	16.7	-	

Table 6. Climatological and hydrological observations made at sockeye salmon smolt counting site, Naknek River, Bristol Bay, Alaska, 1984. A dash (-) indicates data not available.

Date	Cloud Cover 1/		Wind Velocity (km/hr)		Air Temp. (C)	Water Temp. (C)	Precipitation (mm)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr				
5 19	1	3	5 NE	10 NE	-	-	-	murky
5 20	4	3	- -	- -	7.0-21.0	12.0- -	14.35	murky
5 21	5	4	5 SW	8 SW	3.0-18.0	8.5- -	5.21	murky
5 22	4	3	5 W	5 S	6.0-21.0	7.5- 9.0	2.29	murky
5 23	5	2	5 W	5 W	3.0-17.0	8.0-10.0	15.24	murky
5 24	3	3	3 SSE	5 NE	3.0-21.0	8.5-10.0	0.00	murky
5 25	3	3	5 SSE	5 S	2.0-17.0	8.5-10.0	0.60	murky
5 26	5	2	calm	5 SW	0.0- 6.0	8.5-10.0	2.41	murky
5 27	3	2	calm	calm	0.0- 7.0	9.0-10.0	0.00	murky
5 28	2	3	calm	15 SSW	4.0-17.0	10.0-11.5	0.00	murky
5 29	4	4	6 SW	10 SSW	4.0-17.0	9.0- 9.0	0.00	murky
5 30	5	-	2 SSE	5 NNE	2.0-19.0	10.0- 8.5	0.00	murky
5 31	1	1	calm	10 N	-5.0-18.0	9.5-12.0	0.00	murky
6 1	1	1	calm	8 SSW	1.0-22.8	10.0-14.0	0.00	murky
6 2	1	1	calm	15 SSW	-1.0-25.0	- -14.5	0.00	murky
6 3	1	1	calm	5 W	0.0-26.0	7.5-14.5	0.00	murky
6 4	1	1	8 SSE	15 SSW	-3.0-23.0	7.5-14.5	0.00	murky
6 5	5	1	calm	5 SSW	5.6-20.0	8.0-14.0	0.00	murky
6 6	5	1	calm	5 SSW	4.5-15.5	13.5-14.5	0.00	clear
6 7	5	1	7 SSE	5 SSW	5.5-21.5	13.5-14.5	0.00	clear
6 8	5	3	calm	3 SSW	4.0-18.0	11.5-12.0	0.00	clear
6 9	3	3	5 N	5 NNE	4.0-21.5	12.0-14.0	3.81	clear
6 10	4	3	calm	8 SSW	6.5-21.5	12.0-14.0	0.00	clear
6 11	2	1	calm	8 SSW	5.5-21.0	13.0-15.0	0.00	clear
6 12	2	3	calm	3 N	3.0-21.0	12.5-15.0	0.00	clear
6 13	4	1	5 NW	10 NNE	7.2-21.5	14.0-14.5	0.00	clear

-Continued-

Table 6. Climatological and hydrological observations made at sockeye salmon smolt counting site, Naknek River, Bristol Bay, Alaska, 1984. A dash (-) indicates data not available (continued).

Date	Cloud Cover 1/		Wind Velocity (km/hr)		Air Temp. (C)	Water Temp. (C)	Precipitation (mm)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr				
6 14	1	3	calm	8 SSW	5.5-22.0	12.5-14.5	0.00	clear
6 15	4	1	7 SSW	5 NNW	6.5-23.0	13.5-15.0	5.21	clear
6 16	1	3	calm	5 SSE	2.5-25.5	14.0-15.0	0.00	clear
6 17	4	4	calm	2 SSE	9.5-24.0	14.0-14.0	7.11	clear
6 18	3	2	calm	5 SSW	8.3-18.0	13.5-15.5	5.21	clear
6 19	3	2	calm	5 SSW	4.0-23.0	14.5-16.0	0.51	clear
6 20	2	-	3 SSW	-	8.3-23.0	15.0-15.0	0.00	clear
6 21	4	1	calm	5 SSW	7.2-24.5	15.0-15.0	12.70	clear
6 22	3	3	-	15 SSW	7.0-23.0	15.0-15.0	0.00	clear
6 23	4	3	calm	10 NW	4.5-21.0	15.0-14.0	0.51	clear
6 24	4	4	calm	20 NNE	8.0-16.5	15.0-15.0	3.81	clear
6 25	4	3	5 NE	10 NNE	-1.0-15.5	15.0-15.0	3.81	murky
6 26	5	4	10 SE	10 SW	6.0-18.0	15.0-15.0	-	murky
6 27	3	2	2 SE	15 SSE	5.0-20.5	15.0-15.0	0.00	clear
6 28	5	5	2 SE	10 SW	6.0-18.0	15.0-15.0	0.00	clear
6 29	3	4	calm	2 SW	9.5-18.0	15.0-15.0	6.10	clear
6 30	4	4	calm	5 NNE	9.0-15.5	14.0-14.5	0.76	clear
7 1	4	4	calm	3 NNE	8.0-17.0	14.0-14.5	0.00	clear
7 2	5	2	calm	2 N	6.5-15.0	15.0-15.0	0.76	clear
7 3	4	3	3 SW	10 SSW	9.0-21.0	15.0-16.0	0.00	clear
7 4	4	4	5 SSW	10 SSW	8.3-14.5	15.0-15.0	0.00	clear
7 5	4	3	5 SE	10 SSW	10.0-12.5	14.0-14.5	0.76	clear
7 6	4	-	5 SSW	-	9.0-16.5	14.0 -	0.00	clear

- 1/ 1 = cloud cover not more than 1/10
 2 = cloud cover not more than 1/2
 3 = cloud cover more than 1/2
 4 = completely overcast
 5 = fog

Table 7. Water temperatures at sockeye salmon smolt counting site,
Naknek River, Bristol Bay, Alaska, 1967-1984.
A dash (-) indicates data not available.

Year	Sample Period	Water Temperature (C)			Reference
		Minimum	Maximum	Mean	
1967	27 May-11 July	10.6	15.0	13.0	Van Valin (1969a)
1968	21 May-14 July	7.2	16.7	12.9	Van Valin (1969b)
1969	27 May-16 July	6.7	13.9	11.0	Siedelman (1972)
1970	27 May-16 June	11.1	14.4	12.1	Biwer (1972)
1971	7 June- 7 July	4.4	10.0	7.2	McCurdy (1972a)
1972	8 June- 6 July	6.7	14.4	10.1	McCurdy (1974a)
1973	29 May-26 June	6.9	15.9	11.1	McCurdy (1974b)
1974	21 May-27 June	8.1	14.3	12.1	Bill (1975)
1975	28 May- 9 July	3.5	13.2	9.0	Bill (1976)
1976	22 May-26 June	4.6	12.8	9.5	Bill (1977)
1982	21 May-10 July	5.0	14.4	8.9	Huttenun (1984)
1983	20 May- 6 July	8.0	16.0	12.8	Fried and Yuen (in press)
	Mean	6.8	14.1	10.6	
1984	19 May- 6 July	7.5	16.0	13.0	

Table 8. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Egegik River, Bristol Bay, Alaska, 1984. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Sonar Counts				
Transducer Array				
Date 1/	Inshore	Center	Offshore	Total
5 19	4	6	113	123
5 20	335	180	297	812
5 21	2,700	3,653	2,488	8,841
5 22	276	1,428	1,367	3,071
5 23	496	3,410	3,734	7,640
5 24	4,295	7,949	8,880	21,124
5 25	4,285	23,034	120,703	148,022
5 26	57,068	208,915	575,530	841,513
5 27	23,516	137,073	127,426	288,015
5 28	12,742	54,103	162,342	229,187
5 29	5,176	16,074	105,099	126,349
5 30	38,713	96,292	46,145	181,150
5 31	8,176	14,779	3,967	26,922
6 1	11,138	17,563	9,094	37,795
6 2	3,287	4,086	9,521	16,894
6 3	1,325	7,270	4,454	13,049
6 4	2,174	411	945	3,530
6 5	741	1,062	744	2,547
6 6	3,321	1,780	5,719	10,820
6 7	1,562	3,114	2,986	7,662
6 8	2,321	2,986	1,282	6,589
6 9	1,486	2,339	1,543	5,368
6 10	1,384	1,006	923	3,313
Total	186,521	608,513	1,195,302	1,990,336
Percent	9.37	30.57	60.06	

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 9. Daily number of sockeye and coho salmon smolt migrating seaward, estimated with a sonar unit, Egegik River, Bristol Bay, Alaska, 1984.

Sockeye										
Date 1/	Age I		Age II		Age III		All Ages		Coho	
	Number	Percent	Number	Percent	Number	Percent	Daily Total	Cumulative Total	Daily Total	Percent
5 19	1,149	34.84	2,108	63.91	0		3,257	3,257	41	1.25
5 20	5,967	34.84	10,946	63.91	0		16,913	20,170	214	1.25
5 21	62,823	34.84	115,230	63.91	0		178,053	198,223	2,253	1.25
5 22	23,751	34.84	43,565	63.91	0		67,316	265,539	852	1.25
5 23	60,277	34.84	110,559	63.91	0		170,836	436,375	2,162	1.25
5 24	160,745	34.84	294,835	63.91	0		455,580	891,955	5,766	1.25
5 25	1,221,461	34.84	2,240,383	63.91	0		3,461,844	4,353,799	43,820	1.25
5 26	8,117,337	34.84	14,888,677	63.91	0		23,006,014	27,359,813	291,215	1.25
5 27	2,147,798	33.81	4,192,685	66.00	12,069	0.19	6,352,552	33,712,365	0	
5 28	1,996,389	33.81	3,897,122	66.00	11,218	0.19	5,904,729	39,617,094	0	
5 29	1,274,916	36.61	2,123,545	60.97	61,064	1.75	3,459,525	43,076,619	23,218	0.67
5 30	1,465,299	36.61	2,440,652	60.97	70,182	1.75	3,976,133	47,052,752	26,685	0.67
5 31	194,982	36.61	324,770	60.97	9,339	1.75	529,091	47,581,843	3,550	0.67
6 1	175,838	22.95	580,841	75.82	1,762	0.23	758,441	48,340,284	7,661	1.00
6 2	137,465	34.50	254,228	63.80	2,829	0.71	394,522	48,734,806	3,985	1.00
6 3	96,654	34.50	178,751	63.80	1,989	0.71	277,394	49,012,200	2,801	1.00
6 4	9,216	14.49	45,155	71.01	2,855	4.49	57,226	49,069,426	6,358	10.00
6 5	6,329	14.49	31,008	71.01	1,960	4.49	39,297	49,108,723	4,366	10.00
6 6	28,343	14.49	138,861	71.01	8,779	4.49	175,983	49,284,706	19,553	10.00
6 7	19,941	14.49	97,698	71.01	6,177	4.49	123,816	49,408,522	13,757	10.00
6 8	11,929	10.02	96,903	81.37	3,116	2.62	111,948	49,520,470	7,145	6.00
6 9	9,921	10.02	80,593	81.37	2,591	2.62	93,105	49,613,575	5,942	6.00
6 10	5,739	10.02	46,619	81.37	1,499	2.62	53,857	49,667,432	3,437	6.00
Total	17,234,269	34.70	32,235,734	64.90	197,429	0.40	49,667,432		474,781	

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 10. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Egegik River, Bristol Bay, Alaska, 1984.

Date 1/	Mean Weight of Smolt (g)	Smolt per Count
5 19	no sample	5.0
5 20	no sample	5.0
5 21	no sample	5.0
5 22	no sample	5.0
5 23	no sample	5.0
5 24	12.2	3.4
5 25	13.3	3.1
5 26	10.8	3.8
5 27	12.3	3.4
5 28	11.7	3.5
5 29	11.5	3.6
5 30	11.2	3.7
5 31	11.8	3.5
6 1	12.0	3.5
6 2	12.0	3.5
6 3	12.0	3.5
6 4	13.5	3.1
6 5	14.6	2.8
6 6	15.3	2.7
6 7	14.6	2.8
6 8	13.1	3.2
6 9	no sample	5.0
6 10	14.2	2.9

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

A total of 3,612 sockeye and 35 coho salmon smolt were sampled for age, weight, and length information (Tables 11 and 12). Mean weights for age I, age II, and age III sockeye salmon smolt were 10.1, 12.2, and 20.2 g, respectively. Mean lengths of age I, age II, and age III sockeye smolt were 106, 112, and 134 mm, respectively. While 3 age classes of coho smolt were captured (age I, II, and III) only the age II and III were present in significant amounts. Mean length of age II and III coho smolt was 140 and 160 mm, respectively. Mean weight of age II and age III coho smolt was 25.7 and 37.9 g, respectively. Mean sizes of age I and III sockeye smolt were larger than the grand mean for past years while age II sockeye smolt were smaller (1969-1982): age I smolt length and weight, 103 mm and 9.8 g, respectively; age II smolt length and weight, 118 mm and 15.2 g, respectively; age III smolt length and weight, 129 mm and 20.3 g, respectively) (Table 13).

Weather and river conditions were recorded at the sonar site intermittently during 17 May through 11 June (Table 14). Mean air and water temperatures during this period were 9.3°C (range, 5.5-17.0°C) and 7.6°C (range, 5.0-1.0°C), respectively.

Uqashik River

A total of 15,679,789 sonar counts were recorded during the 1984 season, 22 May through 16 June (Table 15). Fifty-six percent of these counts were registered over the inshore array and 44% over the offshore array. Most smolt migration across the counting site transect occurred from the south bank of the river to a point 90 m (297 ft) offshore.

The final sockeye salmon smolt population size estimate was 158,174,626 (Table 16). Age composition was estimated to be 48% age I (1982 brood year), 52% age II (1981 brood year), and less than 1% age III (1980 brood year). Additionally, an estimated 2,494,962 coho salmon smolt migrated seaward during counting operations.

Since larger, and generally older, smolt tended to migrate to sea earlier in the season than smaller smolt, number of smolt per sonar count tended to increase as the season progressed (range, 3.8 to 6.6 smolt per count) (Table 17).

A total of 4,810 sockeye and 24 coho salmon smolt were sampled for age, weight, and length information (Tables 18 and 19). Mean weights of age I, II, and III sockeye salmon smolt were 6.8, 10.3, and 11.7 g, respectively. Mean lengths of age I, II, and III sockeye salmon smolt were 87, 102, and 103 mm, respectively. Mean weight and length of age II coho salmon smolt were 26.6 g and 134 mm, respectively. Mean length of age I smolts was close to the historic average while age II and III sockeye salmon smolt were less than the grand means for past years. Mean lengths were less than the grand means for all three ages (1958-1982: age I smolt weight and length, 6.6 g and 91 mm, respectively; age II smolt weight and length, 12.4 g and 114 mm, respectively; age III smolt weight and length, 18.4 g and 131 mm, respectively) (Table 20).

Table 11. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Egegik River, Bristol Bay, Alaska, 1984.

Date 1/	Age I					Age II					Age III				
	Mean	Std.	Mean	Std.	Sample	Mean	Std.	Mean	Std.	Sample	Mean	Std.	Mean	Std.	Sample
	Length		Weight			Length		Weight			Length		Weight		
	(mm)	Error	(g)	Error	Size	(mm)	Error	(g)	Error	Size	(mm)	Error	(g)	Error	Size
5 24	104	0.4	9.7	0.1	83	116	0.6	13.4	0.2	175					
5 25	107	1.0	10.4	0.2	26	115	1.1	12.9	0.4	74					
5 26	107	0.5	10.4	0.1	86	110	0.7	11.5	0.2	52					
5 27	106	0.5	10.1	0.1	81	115	0.6	13.2	0.2	185					
5 28	105	0.3	9.9	0.1	197	114	0.4	12.8	0.1	331	139	9.0	21.4	3.8	2
5 29	104	0.3	9.7	0.1	103	114	0.8	12.8	0.3	111	138	4.4	23.1	2.5	3
5 30	104	1.2	9.6	0.3	28	112	0.8	11.6	0.3	55	128	5.8	17.3	2.6	3
5 31	104	0.4	9.8	0.1	76	113	0.4	12.6	0.1	173	128		18.3		1
6 1	105	0.3	9.8	0.1	99	113	0.3	12.6	0.1	327	134		20.6		1
6 2	104	0.3	9.7	0.1	85	114	0.5	12.6	0.2	174	125	5.8	17.1	2.3	3
6 3	105	0.3	10.0	0.1	127	114	0.5	12.6	0.2	213	143		25.0		1
6 4	102	1.3	9.3	0.4	4	116	1.6	13.4	0.6	29	125	6.5	17.5	3.2	2
6 5	111	2.3	11.1	0.9	4	116	2.1	13.0	0.7	16	131	4.0	18.4	1.2	2
6 6	106	0.5	10.2	0.2	62	114	0.4	12.6	0.1	204					
6 7	106	0.9	10.3	0.2	12	115	0.7	13.0	0.2	79	126	3.4	16.5	1.3	4
6 8	112	2.4	12.0	0.9	6	114	0.7	12.7	0.2	56	129	3.7	18.3	1.6	3
6 10	105	0.3	10.0	0.1	31	114	0.3	12.5	0.1	221	123	2.5	15.3	1.3	2
Totals					1110					2475					27
Means	106		10.1			112		12.2			134		20.2		

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 12. Mean fork length (mm) and weight (g) of coho salmon smolt captured in fyke nets, Egegik River, Bristol Bay, Alaska, 1984.

Date 1/	Age I					Age II					Age III				
	Mean		Mean		Sample	Mean		Mean		Sample	Mean		Mean		Sample
	Length	Std.	Weight	Std.		Length	Std.	Weight	Std.		Length	Std.	Weight	Std.	
	(mm)	Error	(g)	Error	Size	(mm)	Error	(g)	Error	Size	(mm)	Error	(g)	Error	Size
5 24						137		22.8		3					
5 30	81		5.1		1										
5 31						143		20.0		2					
6 1						167		39.6		1	164		41.2		2
6 2											165		43.7		1
6 4						154		34.9		1	182		46.2		1
6 5						149		29.8		5	142		27.2		1
6 6						140		25.3		4	142		27.0		3
6 7						103		8.7		1	158		39.5		1
6 8						140		26.2		4	164		40.5		3
6 10						131		23.7		1					
	—		—		—	—		—		—	—		—		—
Totals					1					22					12
Means	81		5.1			140		26.4			160		37.9		

1/ Sample day began at 1200 hours and ended at 1159 hrs the next calander day.

Table 13. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Egegik River, Bristol Bay, Alaska, 1939-1984. A dash (-) indicates data not available.

Year of Migration	Sample Dates	Sample Size	Age I		Age II		Age III		Reference
			Mean Length	Mean Weight	Mean Length	Mean Weight	Mean Length	Mean Weight	
1939	-	-	96	-	105	-	-	-	USF&WS (unpublished)
1956	-	386	101	-	116	-	123	-	"
1957	-	236	107	-	120	-	130	-	"
1959	-	281	99	-	116	-	123	-	"
1960	-	159	106	-	115	-	140	-	"
1969	-	67	99	-	119	-	115	-	Paulus (1972)
1977	27-29 May	299	110	11.3	116	13.3	-	-	ADF&G (unpublished)
1978	19-22 May	319	104	10.1	122	15.4	130	18.1	Huttenun (1980)
1981	15 May- 6 June	549	105	9.1	122	16.6	128	19.1	Bue (1982)
1982	27 May-15 June	881	104	9.2	130	17.1	145	23.5	Bue (1984)
1983	17 May- 9 June	2,631	101	9.3	116	13.6	-	-	Fried and Yuen (in press)
		Mean	103	9.8	118	15.2	129	20.3	
1984	10 May-10 June	3,602	106	10.1	112	12.2	134	20.2	

Table 14. Climatological and hydrological observations made at sockeye salmon smolt counting site, Egegik River, Bristol Bay, Alaska, 1984.
A dash (-) indicates missing data.

Date	Cloud Cover 1/		Wind Velocity (km/hr)		Air Temp. (C)	Mean Water Temp. (C)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr			
5 17	3	3	20 SE	15 S	-	-	clear
5 18	3	3	calm	7 NW	-	5.0	clear
5 19	2	3	- -	5 SW	-	7.0	clear
5 20	4	4	5-10 S	15 SE	7.0	6.5	clear
5 21	4	4	calm	5 W	7.5	6.0	clear
5 22	3	2	5 SE	5 SE	9.0	6.0	clear
5 23	4	3	calm	3 NW	6.5	6.0	clear
5 24	3	3	5 E	10 S	5.5	7.0	clear
5 25	3	4	5-10 E	5-10 S	7.5	7.0	clear
5 26	4	4	calm	5 NW	6.0	7.5	clear
5 27	1	1	12 SW	10 SE	7.0	7.0	clear
5 28	4	3	5 W	17 NE	9.0	7.0	clear
5 29	4	2	5 W	5 W	8.0	7.0	clear
5 30	4	-	calm	15 NW	8.0	7.0	clear
5 31	1	1	calm	15 W	10.0	7.0	clear
6 1	1	1	calm	15 W	11.0	8.0	clear
6 2	1	1	10 E	15 SE	14.5	10.0	clear
6 3	1	1	calm	8 W	17.0	10.0	clear
6 4	1	1	5 SE	10 NW	12.0	9.0	clear
6 5	5	1	5 SE	10 N	9.0	8.5	clear
6 6	5	2	calm	5 W	11.5	9.0	clear
6 7	5	2	10 W	5 W	10.0	9.0	clear
6 8	5	3	calm	20 E	7.0	8.5	clear
6 9	4	4	10 E	20 SE	9.0	8.0	clear
6 10	4	3	calm	5 E	12.5	9.0	clear
6 11	3	-	5 E	-	10.0	9.0	clear

1/ 1 = cloud cover not more than 1/10
 2 = cloud cover not more than 1/2
 3 = cloud cover more than 1/2
 4 = completely overcast
 5 = fog

Table 15. Sonar counts recorded from two 10 transducer arrays at the sockeye salmon smolt counting site on the Ugashik River, Bristol Bay, Alaska, 1984. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Sonar Counts			
Transducer Array			
Date 1/	Inshore	Center	Total
5 22	154,119	256,317	410,436
5 23	306,687	292,796	599,483
5 24	276,771	362,298	639,069
5 25	276,771	362,298	639,069
5 26	246,856	431,801	678,657
5 27	702,269	464,371	1,166,640
5 28	171,990	25,406	197,396
5 29	219,498	34,211	253,709
5 30	144,161	495,352	639,513
5 31	1,448,042	895,770	2,343,812
6 1	1,383,188	1,213,644	2,596,832
6 2	386,451	767,742	1,154,193
6 3	1,065,961	388,862	1,454,823
6 4	522,716	59,404	582,120
6 5	207,046	250,753	457,799
6 6	248,857	29,153	278,010
6 7	26,557	12,648	39,205
6 8	148,185	177,485	325,670
6 9	295,959	114,291	410,250
6 10	167,561	20,358	187,919
6 11	113,184	30,840	144,024
6 12	14,128	10,163	24,291
6 13	185,807	79,403	265,210
6 14	70,760	26,924	97,684
6 15	46,669	12,916	59,585
6 16	7,192	27,198	34,390
Total	8,837,385	6,842,404	15,679,789
Percent	56.36	43.64	

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 16. Daily number of sockeye and coho salmon smolt migrating seaward, estimated with a sonar unit, Ugashik River, Bristol Bay, Alaska, 1984.

Date 1/	Sockeye Salmon								Coho Salmon	
	Age I		Age II		Age III		All Ages		Number	Percent
	Number	Percent	Number	Percent	Number	Percent	Daily Total	Cumulative Total		
5 22	820,927	19.43	3,404,125	80.57			4,225,053	4,225,053	0	
5 23	1,106,357	19.43	4,587,712	80.57			5,694,069	9,919,123	0	
5 24	1,265,835	19.43	5,249,017	80.57			6,514,853	16,433,977	0	
5 25	1,397,578	19.43	5,795,309	80.57			7,192,888	23,626,865	0	
5 26	990,062	13.25	6,414,957	85.87	9,711	0.13	7,414,732	31,041,597	56,030	0.75
5 27	1,298,342	13.25	8,412,404	85.87	12,736	0.13	9,723,482	40,765,080	73,477	0.75
5 28	177,028	13.25	1,147,027	85.87	1,736	0.13	1,325,792	42,090,873	10,018	0.75
5 29	224,248	13.25	1,452,980	85.87	2,199	0.13	1,679,428	43,770,301	12,690	0.75
5 30	3,084,115	44.53	3,772,834	54.47			6,856,950	50,627,251	69,264	1.00
5 31	11,902,796	44.53	14,560,832	54.47			26,463,628	77,090,880	267,318	1.00
6 1	12,041,475	44.53	14,730,480	54.47			26,771,956	103,862,837	270,432	1.00
6 2	7,744,682	60.95	4,283,589	33.71			12,028,272	115,891,109	677,649	5.33
6 3	6,858,630	60.95	3,793,513	33.71			10,652,143	126,543,252	600,120	5.33
6 4	3,167,866	60.95	1,752,149	33.71			4,920,016	131,463,269	277,184	5.33
6 5	4,805,407	80.14	1,190,858	19.86			5,996,265	137,459,534	0	
6 6	2,621,560	84.54	479,410	15.46			3,100,970	140,560,505	0	
6 7	362,740	84.54	66,335	15.46			429,075	140,989,580	0	
6 8	3,332,196	86.93	443,500	11.57			3,775,697	144,765,277	57,497	1.50
6 9	3,888,520	86.93	517,544	11.57			4,406,065	149,171,342	67,097	1.50
6 10	1,641,946	88.52	213,045	11.49			1,854,992	151,026,335	0	
6 11	1,402,850	88.52	182,022	11.49			1,584,873	152,611,209	0	
6 12	292,377	95.31	11,318	3.69			303,695	152,914,904	3,067	1.00
6 13	2,937,057	95.31	113,696	3.69			3,050,753	155,965,658	30,811	1.00

-Continued-

Table 16. Daily number of sockeye and coho salmon smolt migrating seaward, estimated with a sonar unit, Ugashik River, Bristol Bay, Alaska, 1984 (continued).

Sockeye Salmon									Coho Salmon	
Date 1/	Age I		Age II		Age III		All Ages		Number	Percent
	Number	Percent	Number	Percent	Number	Percent	Daily Total	Cumulative Total		
6 14	1,040,915	95.31	40,294	3.69			1,081,210	157,046,868	10,919	1.00
6 15	578,658	95.31	22,400	3.69			601,058	157,647,927	6,070	1.00
6 16	507,070	95.31	19,629	3.69			526,699	158,174,626	5,319	1.00
Total	75,491,249	47.73	82,656,993	52.26	26,384	0.02	158,174,626		2,494,962	

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 17. Adjustment factors used to expand sonar counts into estimated numbers of sockeye and coho salmon smolt, Ugashik River, Bristol Bay, Alaska, 1984.

Date 1/	Mean Weight of Smolt (g)	Smolt per Count
5 22	no sample	5.0
5 23	9.7	4.3
5 24	9.5	4.4
5 25	8.6	4.8
5 26	9.1	4.5
5 27	10.4	4.0
5 28	10.6	3.9
5 29	10.8	3.8
5 30	10.0	4.2
5 31	7.6	5.5
6 1	8.7	4.8
6 2	9.3	4.5
6 3	10.3	4.0
6 4	7.9	5.3
6 5	7.3	5.7
6 6	6.3	6.6
6 7	7.6	5.5
6 8	8.1	5.1
6 9	7.4	5.6
6 10	7.2	5.8
6 11	7.0	6.0
6 12	no sample	5.0
6 13	7.0	6.0
6 14	7.2	5.8
6 15	7.5	5.5
6 16	7.1	5.9

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 18. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Ugashik River, Bristol Bay, Alaska, 1984.

Date 1/	Age I					Age II					Age III				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (gm)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (gm)	Std. Error	Sample Size
5 23	84	1.7	6.3	0.3	17	100	0.4	10.3	0.1	103					
5 24	90	1.1	7.2	0.2	28	101	0.3	9.8	0.1	175					
5 25	87	0.6	6.8	0.1	84	100	0.4	9.5	0.1	152					
5 26	89	0.7	7.1	0.2	40	99	0.4	9.2	0.1	155					
5 27	92		7.9		2	103	0.8	10.5	0.2	32					
5 28	89	0.7	7.3	0.2	21	105	0.6	11.2	0.2	110					
5 29	93	1.6	8.2	0.4	21	104	0.5	10.9	0.2	167	103		11.7		1
5 30	89	0.5	7.1	0.1	52	102	0.4	10.3	0.1	177					
5 31	86	0.5	6.2	0.1	63	101	1.3	10.1	0.4	33					
6 1	85	0.5	6.5	0.1	113	103	0.6	10.6	0.2	133					
6 2	88	0.5	6.9	0.1	70	100	0.7	9.7	0.2	40					
6 3	87	0.3	6.8	0.1	94	105	0.8	11.1	0.2	73					
6 4	88	0.3	7.1	0.1	171	100	0.9	10.0	0.3	65					
6 5	87	0.1	6.8	0.1	464	98	0.5	9.3	0.1	115					
6 6	85	0.5	6.1	0.1	89	94	3.0	8.0	0.8	9					
6 7	88	0.2	7.0	0.1	306	99	0.7	9.5	0.2	85					
6 8	87	0.2	6.9	0.1	223	96	0.7	8.9	0.2	41					
6 9	87	0.2	6.9	0.1	239	107	2.5	12.7	1.0	21					
6 10	88	0.2	6.8	0.1	242	98	0.7	9.3	0.2	44					
6 11	87	0.2	6.6	0.1	268	103	2.0	10.6	0.6	22					
6 13	86	0.2	6.8	0.1	190	103	3.3	10.6	1.1	9					
6 14	88	0.3	7.1	0.1	98	103	1.0	11.8	0.6	2					
6 15	88	0.7	6.8	0.2	51	115		15.9		1					
6 16	87	0.3	7.0	0.1	95	98	4.0	9.6	1.1	4					
Totals					3,041					1,768					1
Means	87		6.8			102		10.3			103		11.7		

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 19. Mean fork length (mm) and weight (g) of coho salmon captured in fyke nets, Ugashik River, Bristol Bay, Alaska, 1984.

Age II			
Date 1/	Mean Length (mm)	Mean Weight (g)	Sample Size
5 29	127	23.1	4
6 1	136	27.4	9
6 7	151	37.2	3
6 13	123	18.7	8
	—	—	—
Total			24
Means	134	26.6	

1/ Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 20. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Ugashik River, Bristol Bay, Alaska, 1958-1984. A dash (-) indicates data not available.

Year of Migration	Sample Dates	Sample Size	Age I		Age II		Age III		
			Mean Length	Mean Weight	Mean Length	Mean Weight	Mean Length	Mean Weight	
1958	-	-	93	6.4	112	11.7	-	-	USF&WS (unpublished)
1959	-	-	90	6.1	120	13.5	-	-	"
1960	-	-	90	6.6	104	11.0	-	-	"
1961	-	-	90	6.7	112	12.2	-	-	"
1962	12 May-28 June	1,070	88	6.1	112	12.3	-	-	Jaenicke (1963)
1963	5 May-26 June	921	90	6.1	104	9.6	-	-	Nelson and Jaenicke (1965)
1964	15 May-20 June	4,042	92	6.9	118	12.7	-	-	Nelson (1965)
1965	13 May-20 June	3,296	94	6.9	114	12.5	-	-	Nelson (1966)
1967	15 May-12 June	966	88	6.0	113	12.2	-	-	Nelson (1969)
1968	13 May-24 June	6,727	93	6.5	113	10.7	-	-	Siedelman (1969)
1969	23 May- 6 June	567	97	7.5	121	14.5	-	-	Schroder (1972a)
1970	15 May-10 June	907	97	7.7	125	15.9	-	-	Schroeder (1972b)
1972	28 May-20 June	615	81	5.0	112	11.2	129	14.3	Schroeder (1974a)
1973	17 May-12 June	1,189	93	7.2	113	11.9	132	20.1	Schroeder (1974b)
1974	17 May-17 June	355	94	7.4	119	13.6	-	-	Schroeder (1975)
1975	3-13 June	-	96	7.2	116	13.0	125	16.7	Sanders (1976)
1982	6- 8 June	512	88	6.3	113	13.0	138	22.5	Eggers (1984)
1983	21 May-16 June	9,502	89	7.6	111	13.2	-	-	Fried and Yuen (in press)
		Mean	91	6.6	114	12.4	131	18.4	
1984	23 May-16 June	4,810	87	6.8	102	10.3	103	11.7	

Weather and river conditions were recorded at the sonar site intermittently during 20 May through 17 June (Table 21). Mean air and water temperatures during this period were 9.3°C (range, 5.0-20.0°C) and 6.3°C (range, 4.8-8.5°C), respectively.

Table 21. Climatological and hydrological observations made at sockeye salmon smolt counting site, Ugashik River, Bristol Bay, Alaska, 1984.
A dash (-) indicates missing data.

Date	Cloud Cover 1/		Wind Velocity (km/hr)		Air Temp. (C)	Water Temp. (C)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr			
5 20	4	4	15 W	20 W	5.0	4.8	clear
5 21	4	3	5 W	2 E	5.5	4.8	clear
5 22	4	3	calm	5 NW	6.0	4.5	clear
5 23	4	5	2 NW	-	5.0	4.5	clear
5 24	2	2	calm	5 SE	8.0	5.0	clear
5 25	2	3	calm	5 W	7.0	5.0	clear
5 26	4	1	calm	calm	6.5	5.0	clear
5 27	1	1	5 E	10 E	8.0	5.5	clear
5 28	3	4	15 W	5 W	6.5	5.0	clear
5 29	4	3	10 W	10 W	6.0	5.0	clear
5 30	4	1	5 W	5 W	7.0	5.5	clear
5 31	1	1	calm	calm	9.0	5.5	clear
6 1	1	1	calm	10 E	20.0	6.5	clear
6 2	1	1	25 SE	20 SE	12.0	7.5	clear
6 3	1	1	calm	5 W	20.0	8.0	clear
6 4	1	1	calm	15 E	15.0	6.5	clear
6 5	5	3	calm	5 W	10.0	6.0	clear
6 6	5	2	calm	5 W	10.0	6.5	clear
6 7	4	1	10 E	10 E	8.0	6.5	clear
6 8	5	2	calm	45 SE	7.0	6.0	clear
6 9	4	3	15 SE	15 E	6.0	6.5	clear
6 10	4	3	calm	calm	10.0	7.0	clear
6 11	2	1	calm	5 W	9.5	7.5	clear
6 12	1	2	calm	calm	10.0	7.5	clear
6 13	-	3	-	10 E	10.0	8.5	clear
6 14	1	4	calm	20 W	11.5	8.5	clear

-Continued-

Table 21. Climatological and hydrological observations made at sockeye salmon smolt counting site, Ugashik River, Bristol Bay, Alaska, 1984.
A dash (-) indicates missing data (continued).

Date	Cloud Cover 1/		Wind Velocity (km/hr)		Air Temp. (C)	Water Temp. (C)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr			
6 15	4	1	10 SW	calm	11.0	7.0	clear
6 16	2	3	25 E	25 E	11.5	7.5	clear
6 17	4	-	25 E	-	10.0	8.0	clear

- 1/ 1 = cloud cover not more than 1/10
 2 = cloud cover not more than 1/2
 3 = cloud cover more than 1/2
 4 = completely overcast
 5 = fog

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1984 WOOD RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

Annual numbers of sockeye salmon smolt migrating to sea from the Wood River system have ranged from about 30 million to 100 million smolt since the sonar program began in 1975 (Krasnowski 1976). Most smolt migration has occurred during the 90 day period between 1 June and 30 August. Estimates of smolt numbers are required for forecasting adult returns and determining optimum spawning escapement levels.

Specific objectives of the Wood River smolt project have been: 1) to estimate numbers of seaward migrating sockeye salmon smolt, 2) to describe smolt migration patterns, 3) to determine the age, length, and weight composition of the smolt population, 4) to record the incidence of the cestode parasite *Trienophorus crassus*, and 5) to record climatological and hydrological parameters which might affect migratory behavior.

MATERIALS AND METHODS

The sonar system, described by Krasnowski (1976 and 1977), consisted of four ladder-like arrays anchored on the river bottom at the counting site and an electronic counting unit housed on shore in a canvas wall tent. Each array contained 10 upward facing transducers.

Installation and operation of the sonar gear has been described by Bucher (1980 and 1981). The same counting site has been used since 1975 (Krasnowski 1976). Actual placement of arrays I, II, III, and IV in 1984 were 25.6, 40.5, 53.0, and 68.9 m from the north bank of the river, respectively.

Sonar operation began at 2100 hours on 25 May and continued through 0200 hours on 24 July. Data collection procedures were the same as those used in past years (Bucher 1980). Smolt counting was conducted 24 hours per day as was done in 1982 and 1983 (Bucher 1984). Array I was designated as the index array and operated continuously throughout the season. The other three arrays were operated in a random sequence of 15 minute intervals each hour. Hourly counts for arrays II, III, and IV were estimated by expanding 15 minute counts obtained for each array.

Counting rate of the sonar system was a function of water velocity, which, fluctuated continually with the flood and ebb of the tide. Therefore, counting rate was adjusted as changes in water velocity occurred. To monitor water velocity, a current meter connected to a remote digital readout was installed in the river channel behind array I. Flow measurements were also made behind each of the other arrays, once during each five-day sampling period when tidal influence was minimal. The ratio of water velocity over each array to that over array I was used to adjust counts obtained from array II, III, and IV.

Sonar counts were adjusted to account for smolt migrating through sections of the counting site transect not sonified. Expansion factors used for 1984 data analysis were 5.39, 4.10, 4.24, and 7.21 for arrays I, II, III, and IV, respectively. After these corrections were made, expanded array counts were summed to yield a total daily count.

Finally, the total daily count was adjusted for smolt size to produce an estimate of daily smolt passage. The Wood River sonar system was calibrated to register one count for the biomass equivalent of 26.85 g. Consequently, the daily mean weight of smolt from fyke net catches was used to estimate the number of smolt equivalent to one sonar count.

Smolt samples were obtained by fishing with a fyke net. About 60 smolt per sampling day were weighed (wet weight, g), measured (fork length, mm), and aged (from scale samples). All smolt from daily samples were examined externally for the presence of *T. crassus*. Percent infection of age I and II smolt by this parasite was calculated by five-day periods. Smolt population estimates for each five-day period were used as weighting factors for calculating percent infection.

RESULTS AND DISCUSSION

A total of 893,101 sonar counts were recorded during the season (Table 1). The total sonar counts were distributed at 24,37, 22, and 17% over arrays I, II, III, and IV, respectively. This pattern was similar to that recorded for past years (Table 2).

Estimated total number of smolt migrating seaward was 23,710,891 (Table 3). The migration began on 26 May and 50% of the estimated population had passed the sonar site by 24 June. Age class composition of the smolt population was estimated to be 94.2% age I (1982 brood year) and 5.8% age II (1981 brood year). The majority of age II smolt emigrated during the first two weeks of June.

A total of 2,271 smolt were sampled to obtain data on age, length, and weight (Table 4). Mean lengths of age I and II smolt were 92 mm and 97 mm, respectively. Mean weights of age I and II smolt were 7.8 g and 8.7 g, respectively. Mean length and weight of age I smolt exceeded all previous grand means for 1975-1983 (Table 5). Infection by *T. crassus* within indivi-

Table 1. Sonar counts recorded from four 10 transducer arrays at the sockeye salmon smolt counting site on the Wood River, Bristol Bay, Alaska, 1984. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Sonar Counts					
Transducer Array					
Date 1/	I	II	III	IV	Total
5 26	1,843	1,524	1,294	654	5,315
5 27	5,085	7,976	4,518	1,910	19,489
5 28	2,202	4,882	2,878	3,206	13,168
5 29	856	2,556	3,956	2,412	9,780
5 30	679	2,360	1,980	678	5,697
5 31	5,857	15,770	4,866	7,522	34,015
6 1	3,446	8,576	2,384	2,924	17,330
6 2	1,132	5,122	2,234	1,830	10,318
6 3	1,087	3,299	1,680	1,177	7,243
6 4	1,195	1,076	2,438	1,000	5,709
6 5	4,083	3,699	1,796	588	10,166
6 6	2,334	3,454	880	818	7,486
6 7	7,454	4,435	3,192	2,033	17,114
6 8	7,292	19,604	11,488	7,434	45,818
6 9	2,740	7,446	6,550	2,392	19,128
6 10	4,779	6,382	1,432	974	13,567
6 11	6,714	4,680	3,830	1,534	16,758
6 12	678	1,945	443	544	3,610
6 13	1,755	1,932	810	1,266	5,763
6 14	2,427	3,528	2,274	2,420	10,649
6 15	2,087	2,404	1,120	980	6,591
6 16	2,737	3,528	2,656	1,910	10,831
6 17	1,165	2,610	1,216	587	5,578
6 18	674	630	544	398	2,246
6 19	5,561	8,404	4,622	1,252	19,839
6 20	8,954	11,250	6,106	5,620	31,930
6 21	3,102	4,650	5,076	3,407	16,235
6 22	1,160	3,046	2,440	636	7,282
6 23	2,501	2,736	1,180	1,092	7,509
6 24	2,239	3,740	3,302	1,290	10,571
6 25	7,026	9,338	7,762	9,074	33,200
6 26	7,044	17,940	8,993	7,045	41,022
6 27	8,186	17,873	7,442	4,881	38,382
6 28	1,594	3,897	1,706	7,036	14,233
6 29	2,464	3,416	1,198	2,062	9,140
6 30	9,258	10,030	3,402	4,125	26,815

-Continued-

Table 1. Sonar counts recorded from four 10 transducer arrays at the sockeye salmon smolt counting site on the Wood River, Bristol Bay, Alaska, 1984. False counts were deleted, and interpolations were made for time missed when sonar not operated (continued).

Sonar Counts					
Transducer Array					
Date 1/	I	II	III	IV	Total
7 1	3,370	4,910	2,386	2,809	13,475
7 2	6,018	7,246	4,779	5,424	23,467
7 3	3,733	4,280	3,930	2,688	14,631
7 4	5,251	5,546	2,347	1,858	15,002
7 5	6,046	5,942	3,604	2,166	17,758
7 6	12,604	14,169	7,282	3,923	37,978
7 7	12,764	14,596	10,254	7,548	45,162
7 8	9,046	9,858	6,694	3,064	28,662
7 9	3,392	2,314	2,256	760	8,722
7 10	1,767	2,290	1,208	1,368	6,633
7 11	1,727	1,455	1,240	1,808	6,230
7 12	2,019	2,488	3,456	2,450	10,413
7 13	1,775	5,112	2,218	3,204	12,309
7 14	1,965	5,563	4,684	2,589	14,801
7 15	2,178	3,417	2,470	1,062	9,127
7 16	1,679	2,692	2,220	2,114	8,705
7 17	1,130	1,294	843	1,098	4,365
7 18	675	3,516	1,654	1,478	7,323
7 19	1,411	2,731	3,207	1,254	8,603
7 20	1,714	3,176	1,672	1,604	8,166
7 21	1,361	2,486	2,988	3,322	10,157
7 22	1,392	3,496	4,551	1,715	11,154
7 23	1,098	3,028	2,000	2,004	8,130
7 24	347	502	450	1,302	2,601
Total	213,852	327,845	198,081	153,323	893,101
Percent	23.94	36.71	22.18	17.17	100.00

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 2. Percentage of total unexpanded sonar counts recorded over each array, Wood River, Bristol Bay, Alaska, 1975-1984. False counts were deleted, and interpolations were made for time missed when sonar not operated.

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Percentage of Sonar Counts					
Transducer Array					References
Year	I	II	III	IV	
1975 1/	68.6	31.4	-	-	Krasnowski (1976)
1976	49.0	30.2	11.7	9.1	Krasnowski (1977)
1977	36.0	24.4	20.8	18.8	Newcome (1978)
1978	28.6	29.7	25.6	16.1	Clark and Robertson (1980)
1979	17.0	27.1	33.1	22.8	Bucher (1980)
1980	34.1	35.2	20.5	10.2	Bucher (1981)
1981	39.2	24.8	24.9	11.1	Bucher (1982)
1982	38.2	31.3	15.9	14.6	Bucher (1984)
1983	31.6	29.9	23.5	15.0	Bucher (in press)
Mean 2/	34.2	29.1	22.0	14.7	
1984	23.9	36.7	22.2	17.2	

1/ Only two transducer arrays used.

2/ Data for 1975 omitted.

Table 3. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Wood River, Bristol Bay, Alaska, 1984.

Date 1/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5 26	160,842	97.51	160,842	4,105	2.49	4,105	164,947	164,947
5 27	525,030	97.51	685,872	13,400	2.49	17,505	538,430	703,377
5 28	410,000	97.51	1,095,872	10,464	2.49	27,969	420,464	1,123,841
5 29	359,266	97.51	1,455,138	9,169	2.49	37,138	368,435	1,492,276
5 30	171,778	97.51	1,626,916	4,384	2.49	41,522	176,162	1,668,438
5 31	1,100,703	97.51	2,727,619	28,092	2.49	69,614	1,128,795	2,797,233
6 1	575,140	97.51	3,302,759	14,679	2.49	84,293	589,819	3,387,052
6 2	347,614	97.51	3,650,373	8,872	2.49	93,165	356,486	3,743,538
6 3	228,399	80.84	3,878,772	54,138	19.16	147,303	282,537	4,026,075
6 4	172,445	80.84	4,051,217	40,875	19.16	188,178	213,320	4,239,395
6 5	189,047	80.84	4,240,264	44,810	19.16	232,988	233,857	4,473,252
6 6	195,148	80.84	4,435,412	46,256	19.16	279,244	241,404	4,714,656
6 7	402,760	80.84	4,838,172	95,467	19.16	374,711	498,227	5,212,883
6 8	1,129,418	80.84	5,967,590	267,709	19.16	642,420	1,397,127	6,610,010
6 9	461,586	80.84	6,429,176	109,411	19.16	751,831	570,997	7,181,007
6 10	309,794	80.84	6,738,970	73,431	19.16	825,262	383,225	7,564,232
6 11	501,353	93.18	7,240,323	36,670	6.82	861,932	538,023	8,102,255
6 12	94,404	93.18	7,334,727	6,904	6.82	868,836	101,308	8,203,563
6 13	160,176	93.18	7,494,903	11,715	6.82	880,551	171,891	8,375,454
6 14	320,483	93.18	7,815,386	23,440	6.82	903,991	343,923	8,719,377
6 15	174,811	93.18	7,990,197	12,786	6.82	916,777	187,597	8,906,974
6 16	313,751	93.18	8,303,948	22,948	6.82	939,725	336,699	9,243,673
6 17	131,517	93.18	8,435,465	9,619	6.82	949,344	141,136	9,384,809
6 18	61,753	97.34	8,497,218	1,688	2.66	951,032	63,441	9,448,250
6 19	562,090	97.34	9,059,308	15,373	2.66	966,405	577,463	10,025,713
6 20	818,298	97.34	9,877,606	22,380	2.66	988,785	840,678	10,866,391
6 21	454,149	97.34	10,331,755	12,421	2.66	1,001,206	466,570	11,332,961

-Continued-

Table 3. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Wood River, Bristol Bay, Alaska, 1984 (continued).

Date 1/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
6 22	198,383	97.34	10,530,138	5,425	2.66	1,006,631	203,808	11,536,769
6 23	207,209	97.34	10,737,347	5,667	2.66	1,012,298	212,876	11,749,645
6 24	258,589	97.34	10,995,936	7,072	2.66	1,019,370	265,661	12,015,306
6 25	969,006	97.34	11,964,942	26,502	2.66	1,045,872	995,508	13,010,814
6 26	1,071,432	97.34	13,036,374	29,304	2.66	1,075,176	1,100,736	14,111,550
6 27	915,131	97.34	13,951,505	25,029	2.66	1,100,205	940,160	15,051,710
6 28	444,706	97.81	14,396,211	9,946	2.19	1,110,151	454,652	15,506,362
6 29	219,879	97.81	14,616,090	4,918	2.19	1,115,069	224,797	15,731,159
6 30	653,657	97.81	15,269,747	14,620	2.19	1,129,689	668,277	16,399,436
7 1	274,768	97.81	15,544,515	6,145	2.19	1,135,834	280,913	16,680,349
7 2	559,085	97.81	16,103,600	12,505	2.19	1,148,339	571,590	17,251,939
7 3	344,442	97.81	16,448,042	7,704	2.19	1,156,043	352,146	17,604,085
7 4	334,510	97.81	16,782,552	7,482	2.19	1,163,525	341,992	17,946,077
7 5	333,379	97.81	17,115,931	7,456	2.19	1,170,981	340,835	18,286,912
7 6	696,654	97.81	17,812,585	15,582	2.19	1,186,563	712,236	18,999,148
7 7	997,629	95.93	18,810,214	42,347	4.07	1,228,910	1,039,976	20,039,124
7 8	611,481	95.93	19,421,695	25,956	4.07	1,254,866	637,437	20,676,561
7 9	201,148	95.93	19,622,843	8,538	4.07	1,263,404	209,686	20,886,247
7 10	119,827	95.93	19,742,670	5,086	4.07	1,268,490	124,913	21,011,160
7 11	158,379	95.93	19,901,049	6,722	4.07	1,275,212	165,101	21,176,261
7 12	221,628	95.93	20,122,677	9,407	4.07	1,284,619	231,035	21,407,296
7 13	226,299	95.93	20,348,976	9,606	4.07	1,294,225	235,905	21,643,201
7 14	270,713	95.93	20,619,689	11,491	4.07	1,305,716	282,204	21,925,405
7 15	149,120	95.93	20,768,809	6,329	4.07	1,312,045	155,449	22,080,854
7 16	190,123	95.93	20,958,932	8,070	4.07	1,320,115	198,193	22,279,047
7 17	94,021	95.93	21,052,953	3,991	4.07	1,324,106	98,012	22,377,059
7 18	117,375	95.93	21,170,328	4,982	4.07	1,329,088	122,357	22,499,416
7 19	151,987	95.93	21,322,315	6,451	4.07	1,335,539	158,438	22,657,854

-Continued-

Table 3. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Wood River, Bristol Bay, Alaska, 1984 (continued).

Date 1/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
7 20	166,316	95.93	21,488,631	7,059	4.07	1,342,598	173,375	22,831,229
7 21	312,096	95.93	21,800,727	13,248	4.07	1,355,846	325,344	23,156,573
7 22	257,489	95.93	22,058,216	10,930	4.07	1,366,776	268,419	23,424,992
7 23	199,576	95.93	22,257,792	8,471	4.07	1,375,247	208,047	23,633,039
7 24	74,682	95.93	22,332,474	3,170	4.07	1,378,417	77,852	23,710,891
Total	22,332,474	94.19		1,378,417	5.81		23,710,891	

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Wood River, Bristol Bay, Alaska, 1984.

Date	1/	Age I				Age II					
		Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5	26	88	1.0	5.8	0.2	18	95	0.5	7.6	0.4	2
5	27	87	0.6	6.4	0.1	56	100	-	10.2	-	1
5	28	86	0.4	6.0	0.1	94	104	6.2	9.3	1.4	3
5	29	84	3.5	5.2	0.7	2	-	-	-	-	0
5	30	86	0.8	5.8	0.2	39	-	-	-	-	0
5	31	87	0.5	5.7	0.1	77	102	3.9	8.6	0.4	3
6	1	85	0.5	5.4	0.1	44	-	-	-	-	0
6	2	86	0.5	5.8	0.1	75	92	-	7.4	-	1
6	3	84	0.9	5.1	0.2	16	-	-	-	-	0
6	4	86	0.7	5.5	0.2	22	86	2.6	5.1	0.6	3
6	5										
6	6	86	0.4	6.1	0.1	131	91	1.1	6.9	0.3	15
6	7	90	0.6	6.7	0.1	52	95	1.8	8.2	0.4	16
6	8	88	0.6	6.5	0.1	47	92	1.3	7.5	0.4	13
6	9	89	0.8	6.4	0.2	46	94	1.7	7.4	0.5	14
6	10	88	0.8	6.4	0.1	34	94	1.1	7.6	0.3	26
6	11	86	0.6	6.2	0.1	51	90	1.4	6.7	0.4	9
6	12	86	1.0	6.7	0.2	21	89	1.7	6.9	0.5	4
6	13	87	0.4	6.8	0.1	76	88	2.1	7.0	0.4	7
6	14	86	0.5	6.2	0.1	57	91	2.1	7.4	0.5	3
6	15	88	0.8	6.8	0.1	43	-	-	-	-	0
6	16	88	1.2	6.3	0.3	7	-	-	-	-	0
6	17	88	0.3	7.5	0.1	118	90	2.1	7.0	0.7	4
6	18	91	1.2	7.0	0.3	30	98	1.9	8.8	0.4	3
6	19	89	7.0	6.4	2.0	2	-	-	-	-	0
6	20	91	0.5	7.6	0.1	116	92	3.0	8.6	0.2	2

-Continued-

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Wood River, Bristol Bay, Alaska, 1984 (continued).

Date	1/	Age I				Age II					
		Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
6	21	91	0.8	7.7	0.2	34	96	-	8.7	-	1
6	22	92	0.6	7.2	0.2	61	93	1.1	7.4	0.4	4
6	23	90	0.6	7.5	0.1	53	-	-	-	-	0
6	24										
6	25	91	1.7	7.7	0.5	14	-	-	-	-	0
6	26	91	1.3	7.8	0.3	11	-	-	-	-	0
6	27	95	0.4	8.3	0.1	69	97	1.9	8.5	0.6	3
6	28	95	0.6	7.9	0.1	63	97	1.5	8.2	0.5	6
6	29	95	0.7	8.8	0.2	54	108	5.9	11.7	1.8	3
6	30	95	0.5	8.5	0.1	60	-	-	-	-	0
7	1	99	0.5	10.0	0.2	60	102	4.0	11.0	1.7	2
7	2	95	0.7	8.7	0.2	39	99	-	9.4	-	1
7	3	95	0.9	8.6	0.3	17	-	-	-	-	0
7	4	95	0.5	8.8	0.1	60	-	-	-	-	0
7	5	87	7.1	10.4	0.8	12	-	-	-	-	0
7	6	96	1.8	9.9	0.3	54	-	-	-	-	0
7	7	95	2.0	8.4	0.5	3	-	-	-	-	0
7	8	95	0.5	8.4	0.1	42	-	-	-	-	0
7	9	95	1.7	7.8	0.4	8	-	-	-	-	0
7	10	105	0.5	10.5	0.1	2	-	-	-	-	0
7	11	97	1.3	8.3	0.3	7	-	-	-	-	0
7	12	100	2.7	9.5	0.6	4	-	-	-	-	0
7	13	102	1.1	10.9	0.3	21	113	-	14.1	-	1
7	14	102	1.7	10.4	0.6	15	109	3.5	11.3	1.2	2
7	15	116	16.7	11.4	0.3	52	99	2.5	10.6	1.4	2
7	16	97	1.6	9.3	0.4	7	101	-	10.2	-	1
7	17	98	1.2	9.4	0.4	5	101	1.0	10.1	0.5	2

-Continued-

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Wood River, Bristol Bay, Alaska, 1984 (continued).

Date 1/	Age I					Age II				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
7 18	108	0.5	12.2	0.2	2	-	-	-	-	0
7 19	104	2.6	10.8	0.6	3	-	-	-	-	0
7 20	99	3.5	9.8	1.3	6	-	-	-	-	0
7 21	90	2.5	7.0	0.8	2	-	-	-	-	0
Totals					2,114					157
Means	92		7.8			97		8.7		

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 5. Age composition of total migration, mean fork length (mm), and weight (g) by age class, for sockeye salmon smolt, Wood River, Bristol Bay, Alaska, 1951-1984. A dash (-) indicates data not available.

Year of Migration	Age I			Age II			Total Estimate	References
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)		
1951 1/	80.0	91	-	20.0	-	-	-	Univ. Washington (unpub)
1952	99.0	87	-	1.0	-	-	-	"
1953	95.3	86	-	4.7	103	-	-	"
1954	95.8	87	-	4.2	107	-	-	"
1955	98.0	85	-	2.0	102	-	-	"
1956	78.4	82	-	21.6	95	-	-	"
1957	80.7	77	-	19.3	93	-	-	"
1958	65.0	82	-	35.0	102	-	-	"
1959	93.5	88	-	6.5	105	-	-	"
1960	99.4	88	-	0.6	114	-	-	"
1961	93.0	82	-	7.0	102	-	-	Church (1963)
1962	86.0	80	-	14.0	98	-	-	Church and Nelson (1963)
1963	84.3	83	-	15.7	102	-	-	Nelson (1964)
1964	98.8	84	-	1.2	104	-	-	Nelson (1965)
1965	92.0	86	-	8.0	106	-	-	Nelson (1966)
1966	94.3	77	-	5.7	101	-	-	Siedelman (1967)
1975 2/	86.0	83	-	14.0	98	-	33,850,000	Krasnowski (1976)
1976	95.5	84	-	4.5	95	-	106,200,000	Krasnowski (1977)
1977	82.9	71	3.5	17.1	98	9.3	73,300,000	Newcome (1978)
1978	84.7	79	-	15.3	90	-	55,000,000	Clark and Robertson (1980)
1979	92.2	90	7.6	7.8	100	10.1	65,970,000	Bucher (1980)
1980	96.0	78	4.0	4.0	95	6.8	48,300,000	Bucher (1981)
1981	66.1	88	6.3	33.9	96	8.4	97,530,000	Bucher (1982)

-Continued-

Table 5. Age composition of total migration, mean fork length (mm), and weight (g) by age class, for sockeye salmon smolt, Wood River, Bristol Bay, Alaska, 1951-1984. A dash (-) indicates data not available (continued).

Year of Migration	Age I			Age II			Total Estimate	References
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)		
1982	87.3	79	4.7	12.7	98	8.4	37,060,000	Bucher (1984)
1983	82.6	86	6.5	17.4	98	9.2	23,730,000	Bucher (in press)
		—	—		—	—		
	Mean	80	5.4		96	8.7		
1984	94.2	92	7.8	5.8	97	8.7	23,710,947	

1/ Fyke net catches used to index abundance of smolt, 1951-1966.

2/ Sonar equipment used to estimate numbers of smolt, 1975-1984.

duals of both age classes decreased as the season progressed (Table 6). The incidence of infection was greater for both age groups than the grand mean for 1978-1983 (Table 7).

Smolt numbers in 1984 were low for the second consecutive year, slightly lower than the 1983 estimate (23,710,000 in 1984, 23,730,000 in 1983; range, 1975-1983, 23,730,000 to 106,200,000) (Table 5). Although smolt abundance and timing early in the season appeared to be about average, no sustained migration was observed. The 1981 spawning escapement of 1.23 million produced the second lowest number of smolt per spawner (17.05) and the lowest number of smolt (20.97 million) since the initiation of sonar (Table 8).

Marine survival of smolt can be calculated for the 1973-1978 brood years (Table 9). The data indicates a decreasing trend in age II smolt survival, while survival of age I smolt remained constant.

Water temperature and lake depth measurements were recorded daily at Lake Aleknagik outlet from 22 May until 27 July (Table 10). Minimum and maximum daily water temperatures were recorded on 22-24 May (4.4°C) and 17, 17 July (16.7°C), respectively. Minimum and maximum lake depths were recorded on 27 July (-0.30 m) and 18 June (0.15 m), respectively. Mean water temperature and lake depth for the season were 10.8°C and 0.01 m, respectively. The mean water temperature was 2.4°C greater than the grand mean, while the mean water depth was the lowest on record (Table 11).

Table 6. Infection of sockeye salmon smolts by the cestode Triaenophorus crassus, Wood River, Bristol Bay, Alaska, 1984.

Sample Period	Age I		Age II	
	Number Examined	Percent Infected	Number Examined	Percent Infected
26-30 May	209	63.2	6	83.3
5 May-4 June	234	62.4	7	42.9
6-10 June	310	49.0	84	54.8
11-15 June	248	44.8	23	56.5
16-20 June	273	44.7	9	11.1
21-26 June	173	32.9	5	60.0
27 June- 1 July	306	31.7	14	21.4
2- 6 July	182	26.9	1	0.0
7-11 July	62	33.9	0	0.0
12-16 July	99	34.3	6	50.0
17-21 July	18	38.9	2	0.0
22 July	2	0.0	0	-
Total	2116		157	
Means		41.1		45.7

Table 7. Infection of sockeye salmon smolt by the cestode Triaenophorus crassus, Wood River, Bristol Bay, Alaska, 1978-1984.

Year	Percent Infected		References
	Age I	Age II	
1978	15.1	40.5	Clark and Robertson (1980)
1979	10.0	30.8	Bucher (1980)
1980	11.1	17.3	Bucher (1981)
1981	28.2	35.6	Bucher (1982)
1982	10.0	21.2	Bucher (1984)
1983	43.1	73.6	Bucher (in press)
Mean	19.6	36.5	
1984	41.1	45.7	

Table 8. Sockeye salmon spawning escapements, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1972-1981 brood years, Wood River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Number of Smolt Produced			
		Age I	Age II	Total	Per Spawner
1972	430,000	-	5,900,000	-	-
1973	330,000	27,950,000 (85)	4,800,000 (15)	32,750,000	99.24
1974	1,710,000	101,400,000 (89)	12,550,000 (11)	113,950,000	66.64
1975	1,270,000	60,750,000 (88)	8,400,000 (12)	69,150,000	54.45
1976	820,000	46,600,000 (90)	5,130,000 (10)	51,730,000	63.09
1977	560,000	60,840,000 (97)	1,930,000 (3)	62,770,000	112.19
1978	2,270,000	46,370,000 (58)	33,200,000 (42)	79,570,000	35.02
1979	1,710,000	64,330,000 (93)	4,710,000 (7)	69,040,000	40.37
1980	2,970,000	32,350,000 (89)	4,130,000 (11)	36,480,000	12.28
1981	1,230,000	19,590,000 (93)	1,380,000 (7)	20,970,000	17.05
1982	980,000	22,330,000			

Table 9. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt, for 1972-1982 brood years, Wood River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult Returns	Adult Returns per Smolt	Number of Smolt	Adult Returns	Adult Returns per Smolt
1972	430,000	-	1,411,551	-	5,900,000	55,771	0.01
1973	330,000	27,950,000	1,334,355	0.05	4,800,000	102,717	0.02
1974	1,710,000	101,400,000	4,574,242	0.05	12,550,000	478,861	0.04
1975	1,270,000	60,750,000	3,576,900	0.06	8,400,000	1,110,878	0.13
1976	820,000	46,600,000	4,744,923	0.10	5,130,000	826,181	0.16
1977	560,000	60,840,000	3,382,204	0.06	1,930,000	91,247	0.05
1978	2,270,000	46,370,000	2,485,803	0.05	33,200,000	741,426	0.02
1979	1,710,000	64,330,000	4,620,151	0.07 1/	4,710,000	28,065	0.01 1/
1980	2,970,000	32,350,000	492,677	0.02 1/	4,130,000		
1981	1,230,000	19,590,000					
1982	976,000	22,330,000					

1/ Future adult returns will increase these values.

Table 10. Water temperatures and depths, at field camp site, head of Wood River (outlet of Lake Aleknagik), Bristol Bay, Alaska, 1984. A dash (-) indicates missing data.

	Mean Water Temp. (C)	Mean Water Depth (m)
5 22	4.4	-0.21
5 23	4.4	-0.18
5 24	4.4	-0.17
5 25	5.0	-0.15
5 26	5.5	-0.15
5 27	5.5	-0.15
5 28	5.5	-0.15
5 29	6.7	-0.17
5 30	6.7	-0.18
5 31	6.1	-0.18
6 1	6.1	-0.17
6 2	6.7	-0.15
6 3	7.8	-0.14
6 4	7.8	-0.12
6 5	7.2	-0.06
6 6	6.7	0.00
6 7	7.8	0.03
6 8	8.9	0.03
6 9	9.4	0.05
6 10	10.0	0.06
6 11	10.5	0.08
6 12	10.5	0.09
6 13	11.1	0.09
6 14	12.2	0.11
6 15	11.7	0.12
6 16	12.8	0.14
6 17	11.7	0.14
6 18	10.5	0.15
6 19	10.0	0.14
6 20	8.9	0.12
6 21	9.4	0.11
6 22	10.5	0.09
6 23	8.3	0.06
6 24	7.8	0.06
6 25	7.2	0.06
6 26	7.8	0.06
6 27	8.9	0.08
6 28	10.0	0.09
6 29	10.5	0.12
6 30	11.1	0.15

-Continued-

Table 10. Water temperatures and depths, at field camp site, head of Wood River (outlet of Lake Aleknagik), Bristol Bay, Alaska, 1984. A dash (-) indicates missing data (continued).

		Mean Water Temp. (C)	Mean Water Depth (m)
7	1	12.2	0.20
7	2	13.3	0.20
7	3	14.4	0.21
7	4	15.0	0.23
7	5	15.5	0.21
7	6	15.5	0.21
7	7	14.4	0.20
7	8	11.1	0.18
7	9	12.2	0.15
7	10	14.4	0.12
7	11	13.9	0.11
7	12	14.4	0.11
7	13	15.0	0.09
7	14	15.5	0.09
7	15	16.1	0.08
7	16	16.1	0.05
7	17	16.7	0.02
7	18	12.8	-0.03
7	19	10.0	-0.05
7	20	10.0	-0.06
7	21	12.2	-0.09
7	22	14.4	-0.15
7	23	14.4	-0.21
7	24	15.5	-0.24
7	25	15.5	-0.27
7	26	16.1	-0.30
7	27	16.7	-0.30
Mean		10.8	0.01

Table 11. Water temperatures and depths at field camp site, head of Wood River (outlet of Lake Aleknagik), Bristol Bay, Alaska, 1975-1984. A dash (-) indicates missing data.

Year	Sample Period	Water Temperature (C)			Water Depth (m)			References
		Minimum	Maximum	Mean	Minimum	Maximum	Mean	
1975	29 May-19 July	2.0	9.5	5.0	-0.24	0.57	0.37	Krasnowski (1976)
1976	9 June- 7 August	2.0	14.0	8.0	0.24	1.07	0.57	Krasnowski (1977)
1977	9 June- 8 August	4.5	15.5	9.0	-	-	1.52	Newcome (1978)
1978	28 May- 9 August	5.0	16.0	9.0	0.37	0.98	0.82	Clark and Robertson (1980)
1979	30 May- 2 August	4.5	16.0	9.0	0.33	1.46	0.93	Bucher (1980)
1980	30 May-15 August	4.5	18.0	9.0	0.34	1.65	1.07	Bucher (1981)
1981	27 May-13 August	5.4	17.5	11.4	0.03	1.21	0.55	Bucher (1982)
1982	27 May-10 August	2.2	12.0	6.4	0.46	1.62	1.17	Bucher (1984)
1983	28 May-26 July	4.4	12.8	8.7	0.46	1.19	0.90	Bucher (in press)
	Mean	3.8	14.6	8.4	0.25	1.22	0.88	
1984	22 May-27 July	4.4	16.7	10.8	-0.21	0.23	0.01	

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1984 NUYAKUK RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

A sonar counter was first used to estimate numbers of migrating smolt from the Nuyakuk River in 1983 (Minard and Frederickson 1983). The Nuyakuk River typically accounts for 83% of the sockeye salmon production from the Nushagak River system.

Major objectives of the Nuyakuk River smolt project were: 1) to estimate numbers of seaward migrating sockeye salmon smolt, 2) to describe smolt migration patterns, 3) to determine the age, length, and weight composition of the smolt population, and 4) to record climatological and hydrological parameters which may affect migratory behavior. These data will be used to forecast future returns of adult sockeye salmon to the Nuyakuk system and to aid in evaluating spawning escapement goals.

MATERIALS AND METHODS

Sonar equipment was placed approximately 3.5 km downriver from the outlet of Tikchik Lake (Minard 1984). The river at this site is about 150 m wide and has a maximum depth of 5.0 m. Water velocity was relatively constant during the study period, ranging between 0.70 and 1.15 m/sec.

The sonar system was designed and built by Bendix Corporation in 1982. Equipment consisted of three 3.05 m long ladder-shaped arrays, each housing 10 upward-facing transducers, connected to a single control unit. The offshore array was anchored in the Nuyakuk River on 26 May, while the center and inshore arrays were anchored in the river the following day. Inshore, center, and offshore arrays were situated 21, 47, and 72 m, respectively, from the south bank of the river at the counting site where the control unit was housed in a canvas wall tent. The control unit automatically printed counts (returning echos) from all three arrays every hour, and could also be set to print counts at 7-1/2, 15, or 30 minute intervals.

Counting operations began at 1600 hrs on 27 May and continued until 1200 hrs on 27 June. The sonar system was monitored continuously by field personnel during the project so false counts could be recorded or the counter disabled when the frequency of false counts became very high (e.g., during periods of high winds or heavy rain). False counts were subtracted from total recorded

sonar counts, and counts were estimated by interpolation during times when the sonar system was disabled.

A General Oceanics Model 2031 flow meter was suspended directly behind the inshore array, about 0.5 m below the water surface. Since counting rate of the sonar system depended upon residence time of smolt within transducer beams, which was a function of river velocity as well as smolt swimming speed, current speed data from the meter was used to adjust the current speed setting on the sonar control unit after each hourly printing interval. Counts from the other two arrays were further adjusted for any differences in current speed across the counting transect. This was determined from current speed measurements, collected weekly, behind the center and offshore arrays. Current speeds over the center and offshore arrays averaged 1.120 and 0.996, respectively, times that of the inshore array.

Sonar counts were also adjusted to account for smolt migrating through sections of the river not covered by the three transducer arrays. These adjustments were made using data obtained with a side-scanning sonar counter, built by Bendix Corporation in 1975. These data indicated that the inshore and offshore limits of smolt distribution were 1.52 and 116.43 m, respectively.

A 1.2 m by 2.1 m fyke net was fished in 1.5 m of water about 1 km upriver from the sonar site. Approximately 60 smolt per sampling day were collected for weight (wet weight, g), length (fork length, mm), and age (determined from scale samples) data. Catch per unit effort data were also collected. Mean weight of at least 400 smolt were used to adjust sonar counts after the season, since the sonar system was set at the factory to register one count for the biomass equivalent of five smolt having a mean weight of 8.29975 g.

Climatological and hydrological conditions were recorded daily at the sonar site. Subjective observations were made of cloud cover, wind velocity, and river turbidity, while air and water temperature and precipitation were measured at 0800 and 2000 hrs.

RESULTS AND DISCUSSION

A total of 90,274 sonar counts were recorded for 27 May until 26 June (Table 1). Approximately 68% of these counts occurred over the inshore, 12% over the center, and 20% over the offshore array. The total smolt outmigration estimate was 6,383,556 (Table 2). Age composition was 98.6% age I (6,293,644) and 1.4% age II (89,911) smolt. Peak smolt migration occurred on 28 May, a day after the sonar was installed. All indications (bird activity, rainbow trout abundance, and discussions with local sport fishing guides) prior to the time when sonar was installed and counting would suggest that few smolt had migrated out of Nuyakuk Lake before counting operations began.

A total of 990 smolt were sampled for length, weight, and age data (Table 3). Mean lengths of age I and II smolt were 81 and 93 mm, respectively. Mean weights of age I and II smolt were 4.9 and 7.3 g, respectively. These mean

Table 1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Nuyakuk River, Bristol Bay, Alaska, 1984. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Sonar Counts				
Transducer Array				
Date 1/	Inshore	Center	Offshore	Total
5 27	7,164	167	459	7,790
5 28	19,541	1,635	4,059	25,235
5 29	15,688	3,153	721	19,562
5 30	664	258	661	1,583
5 31	424	125	449	998
6 1	570	119	336	1,025
6 2	1,417	216	572	2,205
6 3	1,242	174	405	1,821
6 4	1,273	297	739	2,309
6 5	466	366	285	1,117
6 6	1,308	312	569	2,189
6 7	485	211	489	1,185
6 8	468	209	236	913
6 9	918	483	529	1,930
6 10	1,310	135	308	1,753
6 11	639	202	384	1,225
6 12	950	237	523	1,710
6 13	467	155	348	970
6 14	958	318	586	1,862
6 15	1,402	321	976	2,699
6 16	929	176	455	1,560
6 17	306	151	274	731
6 18	743	214	311	1,268
6 19	471	174	462	1,107
6 20	405	133	307	845
6 21	183	132	274	589
6 22	246	87	56	389
6 23	82	8	52	142
6 24	256	178	334	768
6 25	496	513	861	1,870
6 26	203	232	489	924
Total	61,674	11,091	17,509	90,274
Percent	68.32	12.28	19.40	100.00

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Nuyakuk River, Bristol Bay, Alaska, 1984.

Date 1/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5 27	489,124	98.66	489,124	6,639	1.34	6,639	495,764	495,764
5 28	1,671,683	98.66	2,160,808	22,692	1.34	29,332	1,694,375	2,190,140
5 29	1,162,910	98.66	3,323,718	15,786	1.34	45,118	1,178,696	3,368,837
5 30	186,985	98.66	3,510,704	2,538	1.34	47,656	189,523	3,558,360
5 31	97,701	98.66	3,608,405	1,326	1.34	48,982	99,027	3,657,388
6 1	58,900	98.66	3,667,305	799	1.34	49,782	59,699	3,717,088
6 2	122,468	98.66	3,789,774	1,662	1.34	51,444	124,131	3,841,219
6 3	132,537	98.66	3,922,312	1,799	1.34	53,244	134,336	3,975,556
6 4	164,051	98.66	4,086,363	2,226	1.34	55,470	166,278	4,141,834
6 5	97,550	98.66	4,183,913	1,324	1.34	56,795	98,874	4,240,708
6 6	161,267	98.66	4,345,181	2,189	1.34	58,984	163,456	4,404,165
6 7	91,065	98.66	4,436,246	1,236	1.34	60,220	92,301	4,496,467
6 8	75,236	98.66	4,511,483	1,021	1.34	61,241	76,257	4,572,725
6 9	161,465	98.66	4,672,948	2,191	1.34	63,433	163,656	4,736,382
6 10	121,756	98.66	4,794,704	1,652	1.34	65,086	123,409	4,859,791
6 11	80,668	98.66	4,875,373	1,095	1.34	66,181	81,763	4,941,555
6 12	120,210	97.38	4,995,584	3,233	2.62	69,414	123,443	5,064,999
6 13	78,845	97.38	5,074,429	2,120	2.62	71,535	80,965	5,145,964
6 14	118,417	97.38	5,192,847	3,184	2.62	74,719	121,602	5,267,567
6 15	205,448	97.38	5,398,295	5,525	2.62	80,245	210,973	5,478,541
6 16	108,814	97.38	5,507,110	2,926	2.62	83,172	111,740	5,590,282
6 17	59,223	97.38	5,566,333	1,592	2.62	84,764	60,816	5,651,098
6 18	84,142	97.38	5,650,476	2,263	2.62	87,027	86,405	5,737,504
6 19	101,545	99.55	5,752,021	455	.45	87,483	102,000	5,839,504
6 20	65,210	99.55	5,817,231	292	.45	87,775	65,502	5,905,007
6 21	51,223	99.55	5,868,455	229	.45	88,005	51,453	5,956,461
6 22	31,831	99.55	5,900,286	142	.45	88,148	31,973	5,988,434

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Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Nuyakuk River, Bristol Bay, Alaska, 1984 (continued).

Date 1/	Age I			Age II			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
6 23	11,893	99.55	5,912,180	53	.45	88,201	11,946	6,000,381
6 24	88,700	99.55	6,000,880	397	.45	88,599	89,098	6,089,480
6 25	197,330	99.55	6,198,211	884	.45	89,484	198,215	6,287,695
6 26	95,433	99.55	6,293,644	427	.45	89,911	95,860	6,383,556
Total	6,293,644	98.59		89,911	1.41		6,383,556	

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 3. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Nuyakuk River, Bristol Bay, Alaska, 1984.

Date 1/	Age I					Age II				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (gm)	Std. Error	Sample Size
5 27	81	11.5	4.9	1.9	2	-	-	-	-	0
5 28	81	11.5	4.9	1.9	2	-	-	-	-	0
5 29	83	0.5	5.2	0.1	90	-	-	-	-	0
5 30	72	4.5	3.2	0.6	3	-	-	-	-	0
5 31	76	3.8	3.8	0.9	3	-	-	-	-	0
6 1	83	-	6.2	-	1	-	-	-	-	0
6 2	83	-	6.2	-	1	-	-	-	-	0
6 3	81	2.0	4.6	0.1	2	-	-	-	-	0
6 4	79	0.4	5.0	0.1	138	87	3.0	7.6	0.8	2
6 5	78	2.8	4.2	0.5	5	-	-	-	-	0
6 6	84	1.3	4.8	0.2	21	90	-	6.1	-	1
6 7	82	1.5	5.0	0.3	18	84	9.5	6.0	1.9	2
6 8	81	1.3	4.4	0.2	11	-	-	-	-	0
6 9	81	2.1	4.4	0.4	3	-	-	-	-	0
6 10	81	1.3	4.8	0.3	21	-	-	-	-	0
6 11	81	0.6	5.4	0.1	104	94	4.0	8.5	1.1	6
6 12	82	0.6	4.9	0.1	57	101	6.7	9.0	1.7	3
6 13	80	0.5	4.6	0.1	60	-	-	-	-	0
6 14	86	0.6	5.6	0.1	57	94	1.7	7.2	0.3	3
6 15	81	0.7	4.8	0.1	59	98	-	7.3	-	1
6 16	83	0.6	5.0	0.1	58	88	2.5	6.3	-	2
6 17	81	0.6	4.7	0.1	60	-	-	-	-	0
6 18	82	0.8	5.2	0.1	58	95	3.5	7.5	0.2	2
6 19	80	1.3	4.3	0.2	9	-	-	-	-	0
6 20	81	1.0	4.9	0.1	56	-	-	-	-	0
6 21	83	5.0	4.6	0.7	2	-	-	-	-	0

-Continued-

Table 3. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Nuyakuk River, Bristol Bay, Alaska, 1984 (continued).

Date 1/	Age I					Age II				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (gm)	Std Error	Sample Size
6 22	79	0.8	4.2	0.1	19	-	-	-	-	0
6 23	80	0.9	4.3	0.1	27	101	-	8.2	-	1
6 24	74	3.6	3.5	0.4	11	-	-	-	-	0
6 25	72	4.6	3.8	0.7	6	-	-	-	-	0
6 26	81	1.2	4.0	0.3	3	-	-	-	-	0
Totals					967					23
Means	81		4.9			93		7.3		

1/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

lengths and weights were larger than the grand means for past years (Table 4).

The 1981 escapement of 834,000 spawners produced an estimated 28.97 million smolt or 34.7 smolt per spawner (Table 5). The low number of age I smolt estimated in 1984 indicates possible low production from the 1982 escapement.

Climatological and hydrological observations were recorded at the sonar site from 27 May until 27 June (Table 6). Ice covered Nuyakuk Lake when the sonar project began, but melted in place during the first two weeks of operations. Mean air and water temperatures for the season were 12.3 and 8.2°C, respectively. Seasonal rainfall totaled 57.6 mm, an average of 1.8 mm per day.

Table 4. Age composition of total migration, and mean fork length (mm) and weight (g) by age class, for sockeye salmon smolt, Nuyakuk River, Bristol Bay, Alaska, 1978, 1982-1984.

Year of Migration	Sample Dates	Sample Size	Age I		Age II		References
			Mean Length (mm)	Mean Weight (g)	Mean Length (mm)	Mean Weight (g)	
1978	18-19 June	350	71	4.3	85	5.8	Huttunen (1980)
1982	15 June- 9 July	208	76	3.9	96	6.8	Minard (1984)
1983	27 May-30 June	1,847	75	4.3	91	6.6	Minard and Frederickson (in press)
			—	—	—	—	
		Mean	74	4.1	91	6.3	
1984	27 May-26 June	980	81	4.9	93	7.3	

Table 5. Sockeye salmon spawning escapements, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1980-1982 brood years, Nuyakuk River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Number of Smolt Produced			
		Age I	Age II	Total	Per Spawner
1980	3,027,000	-	1,259,000	-	-
1981	834,000	28,875,000 (99)	90,000 (1)	28,965,000	34.73
1982	538,000	6,294,000			

Table 6. Climatological and hydrological observations made at sockeye salmon smolt counting site, Nuyakuk River, Bristol Bay, Alaska, 1984.
A dash (-) indicates missing data.

Date	Cloud Cover 1/		Wind Velocity (km/hr)		Mean Air Temp. (C)	Mean Water Temp. (C)	Water Clarity	Precipitation (mm)
	0800 hr	2000 hr	0800 hr	2000 hr				
5 27	1	3	- -	5 SE	6.6	5.0	clear	2.5
5 28	3	3	calm	calm	12.7	5.0	clear	0.0
5 29	3	4	calm	5 NW	8.8	5.0	clear	5.0
5 30	3	3	calm	15 NW	8.6	5.2	clear	0.0
5 31	1	2	calm	calm	13.8	5.2	clear	0.0
6 1	1	2	calm	calm	15.0	5.5	clear	0.0
6 2	1	1	calm	calm	16.1	6.1	clear	0.0
6 3	2	2	calm	5 NW	16.1	6.6	clear	0.0
6 4	3	2	5 NW	calm	16.9	6.6	clear	0.0
6 5	5	4	calm	10 NW	8.8	9.2	light brown	3.0
6 6	3	3	calm	5-10 W	14.4	9.2	light brown	5.0
6 7	2	4	calm	10-15 SW	14.4	9.4	light brown	0.0
6 8	5	3	calm	calm	11.3	8.3	light brown	0.0
6 9	4	3	calm	calm	10.0	6.9	light brown	5.0
6 10	3	3	calm	5 N	13.1	6.9	light brown	0.0
6 11	1	3	calm	calm	16.6	7.7	light brown	0.0
6 12	1	2	calm	calm	13.8	9.4	light brown	2.0
6 13	1	3	5-10 NE	0-3 NE	13.8	10.5	light brown	1.1
6 14	2	2	calm	calm	12.2	10.8	light brown	7.0
6 15	3	3	10-15 NE	5-10 NE	13.3	11.1	light brown	0.0
6 16	2	3	calm	calm	12.2	11.7	light brown	5.5
6 17	4	4	0-5 SE	calm	10.5	9.2	light brown	2.0
6 18	4	2	calm	calm	10.8	7.7	light brown	1.0
6 19	2	2	5 NE	10-15 SE	13.6	10.0	light brown	0.0
6 20	1	4	5-15 NE	calm	14.2	11.1	light brown	2.0
6 21	4	3	5 NE	calm	11.1	11.1	light brown	0.0

-Continued-

Table 6. Climatological and hydrological observations made at sockeye salmon smolt counting site, Nuyakuk River, Bristol Bay, Alaska, 1984.
A dash (-) indicates missing data.

Date	Cloud Cover 1/		Wind Velocity (km/hr)		Mean Air Temp. (C)	Mean Water Temp. (C)	Water Clarity	Precipitation (mm)
	0800 hr	2000 hr	0800 hr	2000 hr				
6 22	5	4	5-10 SW	10-15 E	9.4	10.5	light brown	3.0
6 23	4	4	calm	calm	8.8	9.4	clear	6.5
6 24	4	4	10-30 SW	5 NE	10.0	7.2	clear	7.0
6 25	4	4	calm	calm	12.7	7.2	clear	0.0
6 26	3	3	5-10 SW	1-5 E	14.4	8.0	clear	0.0
6 27	2		calm	- -	10.0	9.4	clear	0.0

- 1/ 1 = cloud cover not more than 1/10
 2 = cloud cover not more than 1/2
 3 = cloud cover more than 1/2
 4 = completely overcast
 5 = fog

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